THE DEVELOPMENT OF THE AMERICAN GLASS INDUSTRY

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To

L. B. D.

PREFACE

THE FIRST PURPOSE of this study is a historical account of the economic evolution of glass manufacture in the United States, reviewing the industry's changing quantitative and qualitative aspects, its technical and mechanical progress, and its progressive adjustments in the expanding American economy. A brief summary of the history of the art of glass in Europe furnishes a background for the description of early glassmaking in America. The growth of the glass industry during the eighteenth and nineteenth centuries is explained in terms of the nature and amount of glass produced, the raw materials and fuels utilized, the processes and techniques of glass-forming employed, and the factors affecting location of the industry. The spectacular events that dominate the industrial history of glass manufacture after 1890 are related in an extensive account of the advent and fruition of mechanical revolution in the several major branches of glass production.

A second purpose of the study falls within the field of labor history. The description of the rise of organized labor in glassmaking, the forms of early union organization, the nature and consequences of union policies, and the impact of mechanical revolution on the status of the unionized worker furnish a chapter in the development of American unionism hitherto largely inaccessible.

A third purpose is an analysis of the interrelationships between the tariff policy of the United States and the growth of glassmaking. In evaluating a long-sustained policy of tariff protection to an important segment of American industrial activity, emphasis is directed to the effect of protectionist policies on technological progress in glass manufacture and on the general competitive position of the industry in this country.

The industrial scope of this history of American glass manufacture has been limited to four major divisions of the industry — the window glass, the plate glass, the glass bottle and con-

tainer, and what may be called the pressed and blown (or flint and lime) glass industries. Little or no consideration has been given to the "special glass" branches: those devoted, for example, to the production of optical glass and glassware, scientific glassware, "art" glassware, and secondary, or re-working, glass processes. Whenever and wherever possible, the influence of such groups has been eliminated from statistics of production and importation.

The time interval spanned by the account begins with the early years of the seventeenth century and ends with the expiration of the first quarter of the twentieth century, thus bringing into review approximately three hundred years of American glassmaking. By 1925, after three decades of industrial revolution, American glass processes had been transformed. Handicraft production had been largely eliminated from the major divisions of the industry, mechanization was triumphant in most lines of production, heavy capital investment and large-scale production reflected the fact that glass manufacture in the United States had become a typical large-scale, mass-production American industry. The end of the first quarter of the twentieth century therefore marks the conclusion of an era in American glassmaking; consequently it is appropriate that the present work terminate at that point. No attempt has been made in this volume to survey the history of the industry in recent years, a period during which a wide array of new processes, new products, and new uses enabled the glass industry to embark on a new and wholly different era of expansion.

Many different and varied source materials have been utilized, directly or indirectly, in the preparation of this study. These include colonial records; village, town, and state histories; accounts of travel written by both Americans and foreign visitors; memoirs and diaries reflecting the life, customs, and industrial practices of the times; letters, tracts, and brochures; sketches of the growth of the industry or of portions of the industry in particular areas and during particular periods; collectors' manuals, both old and new; general industrial histories and monographs recording fragments of industrial

history; official state papers and legislative documents; papers and tracts in scientific journals; newspapers and general periodicals; labor union publications and trade papers; and official governmental studies and reports. These sources, when used directly, are cited in footnotes; the numerous background sources not directly employed are not cited but will be found primarily in Widener library at Harvard University and in the Library of Congress.

Because almost all import data utilized in this volume are adjusted data, readers should not expect to find the import figures employed in exact correspondence with unadjusted figures of glass imports published or reproduced either by governmental or private sources. A number of the adjusted glass import time series utilized in the analysis phase of the study and selected for publication will be found in the Appendix.

In the course of the research necessary to the preparation of this volume, valuable assistance was received from a number of American glass companies. Permission to visit numerous glass factories owned by these companies was graciously granted, and the information gained thereby greatly facilitated the preparation and completion of the study.

Indebtedness to the Belgian-American Educational Foundation of New York City is also acknowledged. An Advanced Fellowship granted by the Foundation afforded opportunity for study in Belgium of the status and development of the Belgian glass industry.

To Professor Arthur Harrison Cole, Curator, Baker Library, Harvard University, I owe a great debt for inspiration and guidance both in the original undertaking of this study and in its subsequent development.

To Professor Abbot Payson Usher, also of Harvard University, I am most grateful for the lively and helpful interest which he displayed at all the various stages in the evolution of this volume.

Chicago, December, 1948 P. D.

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The Origin of Glassmaking

Nothing is known of the craftsmen who first formed from glass objects of beauty and usefulness. Their identity and the time and place of their activity are enveloped in the seemingly depthless mist which shrouds the life of remotest times. Of the extreme antiquity of the art, however, there is no question. Indeed, archaeological research has repeatedly set back the probable date of discovery until the history of glassmaking is now computed in terms of thousands of years. And as well established as its antiquity is the state of excellence and perfection to which the art was brought in both ancient and early modern times.

A romantic account of the origin of glassmaking is given in the *Natural History* of Pliny. A vessel laden with niter, he says, one day moored at the mouth of the river Belus in Phoenicia and a party of merchants proceeded to the beach for the preparation of their food. Not finding at hand any stones upon which to support their cauldrons, they brought from the ship blocks of niter and built a fire between them. Soon they discovered, to their amazement, that where the sand contacted the niter the fire fused the two into streams of transparent liquid. "This," in the words of Pliny, "was the origin of glass."[1]

Pliny's attractive tale has been recounted time and again and appears even in some modern writings on the history of glass and glassmaking. Earlier writers repeat it faithfully, usually without critical comment. Not so the majority of contemporary authors. They look upon the account as sheer

[1] John Bostock and H. T. Riley, *The Natural History of Pliny* (1857), VI, 379.

fable, intriguing to be sure, especially in its affinity to Lamb's famous account of the Chinese discovery of the art of roasting meat, but fable none the less. Until recently such skepticism seemed the only possible attitude for anyone conversant with the rudiments of glass technology. For it appeared altogether beyond the realm of possibility that an open fire, especially one for the preparation of food, should have been able to generate the extreme temperatures necessary to the fusion of glassmaking ingredients. Latest research, surprisingly enough, indicates that the apparent conflict of data may be capable of explanation without resort to fancy. Although the Phoenician merchants did not in truth make glass, they may well have observed a phenomenon which led to the discovery of glass. The noted authorities on English glass, Alexander Nesbitt and Harry James Powell, present this thesis in an ingenious and convincing reinterpretation of Pliny's tale.

> The tradition, recorded by Pliny . . . assigns the discovery of glass to Syria, and the geographical position of that country, its forests as a source of fuel, and its deposits of sand add probability to the tradition. The story that Phoenician merchants found a glass-like substance under their cooking pots, which had been supported on blocks of natron, need not be discarded as pure fiction. The fire may well have caused the natron, an impure form of carbonate of soda, to combine with the surrounding sand to form silicate of soda, which, although not a permanent glass, is sufficiently glass-like to suggest the possibility of creating a permanent transparent material. Moreover, Pliny (XXXVI. 66) actually records the discovery which effected the conversion of deliquescent silicate of soda into permanent glass.[2]

A second theory of the origin of glassmaking, and one

[2] Alexander Nesbitt and H. J. Powell, "History of Glass Manufacture," *Encyclopaedia Britannica,* 11th ed. (1911). Their theory derives strong support from the results of an experiment conducted in this country. A prominent glass manufacturer attracted by Pliny's story determined to test its scientific possibilities. He built a large open fire over a bed of sand and, by maintaining it for two hours, achieved a maximum temperature of 2210° F. Subsequent examination of the sand beneath the fire, however, showed no trace of fusion. The experiment was then repeated but this time with an equal portion of soda mixed with the sand. The result was precisely what Nesbitt and Powell suggest, a fused vitreous mass — silicate of soda.

which has considerable evidence to support it, links glassmaking with the older art of metallurgy. As is well known, many metallurgical operations produce in their vitreous slag a coarse colored glass, and it is possible that this may have suggested and led to the manufacture of glass as a direct product. Moreover, it has been pointed out not only that most of the oldest specimens of glass are colored but also that in so far as these specimens have been analyzed, the coloring matter has proved metallic. Further, the extreme variability in the composition of antique colored glass has also led to the conclusion that many of the specimens are merely metallurgical slags remelted. Another pertinent point is that much of the ancient glass is cast. "These facts certainly indicate, if its discovery was not due to this older art, that metallurgy had an important influence on early glass-making." [3]

Great Glassmaking Nations of Ancient Times

Though it remains undeniably true even today that nothing positive is known either of the method of the discovery of glass or of the time of its discovery, all authorities agree that three nations of ancient times — Egypt, Phoenicia, and Rome — were and are justly celebrated for the achievements of their artists in glass. It is a matter of dispute which of the first two nations is entitled to precedence in the history of the art. Weeks, who reflects the opinion of the majority of students, places Egypt first and estimates that glass manufacture there was an established art from four to six thousand years ago. Within that period the craft seems to have been brought to a state of amazing perfection. He continues:

The art of blowing glass into bottles, fashioning it into vases and drinking-cups, pressing it into various shapes, especially figures of deities, sacred emblems and coins, forming it into huge masses for pillars, adapting it for mosaic art, coloring it to imitate precious stones,

[3] J. D. Weeks, *Report on the Manufacture of Glass* (1884), p. 59. Weeks's careful and thorough study of the history of glassmaking, though now somewhat out-of-date, was one of the first attempts to coördinate the data pertinent to the history of glassmaking. Even yet it is stimulating, suggestive, and convenient. On occasion I have drawn upon it heavily.

the color being of surpassing brilliancy, working it into beads or necklaces, these and similar processes were well known and practiced with great skill . . . The invention of the art of blowing glass, which is unmistakably figured on the tombs of Mastaba of Tih, at Memphis, and on the tombs at Beni-Hassan, is as remarkable as the discovery of glass itself, and would indicate an advance in the art that, in that day of slow development, must have required many centuries to evolve.[4]

Nesbitt and Powell, however, are of another opinion, despite the fact that the geographic conditions and resources were favorable to the early development of the glass industry in Egypt.

No traces have at present been found of the industry in a rudimentary condition . . . The earliest specimens of glass-ware which can be definitely claimed as Egyptian productions, and the glass manufactory discovered by Dr. Flinders Petrie at Tell el Amarna, belong to the period of the XVIIIth dynasty. The comparative lateness of this period makes it difficult to account for the wall painting at Beni Hasan, which accurately represents the process of glass-blowing, and which is attributed to the period of the XIth dynasty. Dr. Petrie surmounts the difficulty by saying that the process depicted is not glass-blowing, but some metallurgical process in which reeds were used tipped with lumps of clay . . . The scarcity of specimens of early glass-ware actually found in Egypt, and the advanced technique of those which have been found, lead to the supposition that glass-making was exotic and not a native industry.[5]

These facts, their belief in the accuracy of Pliny's record, and the continuous discovery of glass near the river Belus, tempt Nesbitt and Powell to accord priority of glass manufacture to Syria. But they say in conclusion, "The claims of Syria and Egypt are at the present time so equally balanced that it is advisable to regard the question of the birthplace of the glass industry as one that has still to be settled." [6]

Whether they led or followed Egypt in point of time, it seems

[4] Weeks, p. 59.
[5] Nesbitt and Powell.
[6] Nesbitt and Powell.

established that the Syrians carried their level of attainment in glass manufacture at least as far as the Egyptians and may well have surpassed them. One writer says:

They knew the effect of an addition of manganese to the frit of sand and soda in making glass clearer. They used the blowpipe, the lathe, and the graver, and cast mirrors of glass. They must also have been acquainted with the art of imitating precious stones and coloring glass by means of metallic oxides. The "pillar of emerald" which Herodotus speaks of (ii,44) in the temple of Hercules at Tyre, "shining brightly in the night" can hardly have been anything else than a hollow cylinder of green glass, in which, as at Gades, a lamp burnt perpetually.[7]

Such evidence as we possess indicates that Egyptian glassworks, and Syrian too, continued to produce long after the end of the Roman era. There exist in fact certain museum pieces which have been identified as Egyptian products of the fourteenth century; if this be so, Egyptologists may fairly claim for that country the longest history of glass manufacture known to man.[8]

The glassmakers of Rome came into prominence only at a comparatively late date, long after glass objects from Egypt and Syria had come to be universally acknowledged as specimens of supremacy in the art. It is contended, moreover, that they were directly and wholly indebted to Egypt for the basic processes upon which they built in the subsequent period of their success and fame. "By purchase or by threats . . . the long fusion, remelting the frit, and the slow cooling, that had given much of its reputation to Egypt, became the property of Rome."[9]

Like their predecessors, Roman craftsmen became famous for their skill in manipulation and the taste of their design. They made "as beautiful objects of the glass-makers' art as have been produced in any age of the world."[10] But their ac-

[7] John Kenrick, *Phoenicia* (1855), p. 249.
[8] Weeks, p. 60.
[9] Weeks, p. 62.
[10] Weeks, p. 62.

complishments were not limited to the realm of the artistic; they succeeded in substantially reducing the cost of at least a large portion of the products that came from their furnaces, a development which is said to have come about primarily because of their truly extensive scale of operations. "With the wealth and luxury of the empire came a demand for glass that stimulated its manufacture and use to a degree of development that has, in some respects, never been excelled, and perhaps never equalled." [11] The Romans employed glass in a wide range of uses.

> It may appear a somewhat exaggerated assertion that glass was used for more purposes . . . by the Romans of the imperial period than by ourselves in the present day; but it is one which can be born out by evidence. It is true that the use of glass for windows was only gradually extending itself at the time when Roman civilization sank under the torrent of German and Hunnish barbarism, and that its employment for optical instruments was only known in a rudimentary stage; but for domestic purposes, for architectural decoration and for personal ornaments glass was unquestionably much more used than at the present day . . . Glass was largely used in pavements, and in thin plates as a coating for walls. It was used in windows, though by no means exclusively . . . Glass, in flat pieces, such as might be employed for windows, has been found in the ruins of Roman houses, both in England and in Italy, and in the house of the faun at Pompeii a small pane in a bronze form remains. Most of the pieces have evidently been made by casting, but the discovery of fragments of sheet-glass at Silchester proves that the process of making sheet-glass was known to the Romans.[12]

From Rome the art of glassmaking was carried to many lands throughout the length and breadth of the Empire — to France, Spain, and Germany, although in the first two countries at least there is evidence that glass furnaces operated even before the coming of the Roman legions.[13] Early glass manufacture in England is of especial importance, but the facts are obscure. It is clearly questionable that glass was made there prior to Roman

[11] Weeks, p. 62.
[12] Nesbitt and Powell.
[13] Weeks, p. 63.

times and it is not definitely established that the Romans made glass in England.[14]

Although glass manufacture was carried on at various and scattered localities after the end of Roman domination, the great traditions of the past fell into neglect and in certain areas became all but forgotten. To the general trend of decline, however, there was one important exception. From the sixth century there occurred a remarkable growth in the manufacture of "broad" or glazing glass. A function of ecclesiastical demand, turned now into grand concepts of architectural splendor, this development reached its height in the superb stained and colored window glass of the cathedrals. Indeed, we may well say with Thorpe that the art of glass generally was a "little dinghy . . . towed through the Middle Ages by the great ship of 'stained glass.' "[15]

The Origin of Modern Glassmaking

In the course of time, at Venice, Murano, and other Italian cities, there appeared worthy claimants and progenitures of the art of Egypt, Syria, and Rome. From the rise of the Venetian glassmen, moreover, may be dated the history of modern glassmaking.[16] Because of these craftsmen glass manufacture spread anew over the countries of western Europe.

By the thirteenth century the glass products of Venice had already come into some prominence, but it was not until the sixteenth and seventeenth centuries that the Italian workers reached the peak of their preëminence. The fame of Venetian glass and craftsmen became so great that strenuous efforts were necessary to prevent emigration of both men and processes. Jealous neighboring states — England, France, and Flanders among others — offered all manner of inducements to the end

[14] H. J. Powell, *Glass-Making in England* (1923), p. 2; Weeks, p. 64.

[15] W. A. Thorpe, *English Glass* (1935), pp. 78–79, 81.

[16] Although Venetian glass eventually became so famous that it acquired the status of a generic name, "much so-called Venetian glass was not made at Venice, but in other Italian glassworks (Treviso, Mantua, Padua, Ferrara, Ravenna, Bologna, Florence, etc.), to which the technique was generally brought by renegade Venetians. The most serious competition, however . . . came from Altare, near Genoa." (Robert Schmidt in *Encyclopaedia Britannica*, 14th ed. [1929], X, 402.)

that they too might partake of the finest fruits of the art. In 1275 the Venetian Council of Ten prohibited the exportation of glassmaking materials. Twenty years later this edict was renewed and a heavy fine levied on all glassworkers who left Venice for other nations. In 1474 the penalty for such action was set at no less than death.[17] These regulations were, however, but part of a wider and more comprehensive code rigidly governing almost every aspect of glass production. Venice indeed may have originated the tradition of regulatory organization in the glass industry, a tradition which persisted especially among the workers even into the early years of the twentieth century. Deming Jarves's sketch of glassmaking at Murano makes this abundantly clear.

During the period of its greatest prosperity (the fifteenth, sixteenth, and seventeenth centuries) Murano counted 30,000 inhabitants . . . Each owner of a factory was obliged to contribute annually a certain sum into a common fund for the succor of the unfortunate of their own class, poor and infirm artisans, or those out of employment, and for the maintenance of the schools of inventive design. No apprentice could be admitted as a master-workman before passing a strict examination in his art and proving his skill in the manufacture of certain objects. The candidate was elected into the body of masters by their secret ballots. Each factory was subject to inspection, night or day, by certain officers, whose duty was to see that the work was regular according to statutes, to note the quantity and quality of the objects, and that no glass in fragments or cullet be exported. Proprietors and master-workmen of ten years' experience, if they honorably failed and had no other means of subsistence, were entitled to pensions of 70 ducats annually. When there were more master-workmen than could be profitably employed, it was forbidden to increase their number from the apprentices until there was a real call for new hands. Whoever became a member of the guild was obliged to take an oath of fidelity. No one who had not a regular discharge from his employer could be received into the service of another, and every proprietor was obliged to seal his cases with his own trade-mark. It was forbidden to employ strangers under any pretense. If there were not enough of the Muranese at times for labor, or to exercise the art, Venetians only might have the privilege, but they must be duly qualified.[18]

[17] Weeks, p. 65.
[18] Weeks, p. 65, quoting Jarves.

Partly to augment the secrecy and high mystery of the art and partly because of the pecuniary worth and industrial position of the craftsmen themselves, the Venetians conferred "the title of 'Gentleman' (no idle title in those days) on all who became accomplished in the manufacture." [19] They were, moreover, permitted to marry into nobility.

> So useful were the glass-makers at one period in Venice, and so considerable the revenue accruing to the republic from their manufacture, that, to encourage the men engaged in it to remain in Murano, the Senate made them all Burgesses of Venice, and allowed nobles to marry their daughters; whereas, if a nobleman marries the daughter of any other tradesman, the issue is not reputed noble.[20]

Heightened social position, which like the strict regulation of the customs of the craft seems to have first made its appearance at Venice, subsequently carried into other glassmaking countries, especially France.[21]

From Venice, to repeat, can be traced the beginning of modern glassmaking in most if not all of the nations of the Western world. For despite the stringent regulations of the Venetian overseers, skilled craftsmen were gradually but persistently induced to try their fortunes abroad. In this way activity began or was renewed in many subsequently important European glass-manufacturing centers. In France, for example, in 1572 a "gentilhomme de Murano," Salviati, and a number of fellow-countrymen came to Poitiers to revive an ancient and once prosperous industry. Henry IV in 1598 allowed two "gentilshomme verriers" from Mantua to settle at Rouen for the manufacture of "verres de cristal, verres dores, emaulx, et autres ouvrages qui se font a Venise." [22] Jean Baptiste Colbert, the French statesman, attempted in 1664 to draw glassworkers to France by commissioning his ambassador to obtain a number of them. The ambassador, it is said, refused on the grounds that he ran

[19] Deming Jarves, *Reminiscences of Glass Making,* 2nd ed. (1865), p. 21.
[20] Jarves, 2nd ed., p. 22, quoting the author of *Analysis of Nobility in its Origin,* Baron Von Lowhen.
[21] Jarves, 2nd ed., pp. 25–27.
[22] Weeks, p. 66.

the risk of being thrown into the sea if it became known that he had done so. A year later, however, by some maneuver unrecorded, eighteen Venetians were actually secured. These workers, first established at Paris in the manufacture of mirrors, later were transferred with others to Saint-Gobain. Thus commenced the history of the famous plate-glass company of that name. In Spain in the sixteenth and seventeenth centuries there occur repeated references to domestically produced glassware that is much like the Venetian. Undoubtedly such resemblance as there was could be attributed to emigrant Italian workers. In Flanders in the first half of the seventeenth century certain Muranese workers were given the privilege of making glass, and at Brussels in 1642 John Savonetti established a glassworks upon grant of an absolute prohibition of imports. The influence of Italian craftsmen was of importance in England, too. To cite but one instance, on June 13, 1550, eight Muranese glassworkers were released from a London prison and allowed to pursue their craft. They had come to England upon the offer of considerable sums of money.[23] In similar fashion glassworks were founded at Antwerp, Liége, Amsterdam (1597), Haarlem, The Hague, Vienna (as early as 1428), Halle (1534), Nuremberg, Munich, Cassel, Cologne, Kiel, Dessau, Copenhagen, Stockholm, Lyons, Argentieres, Nantes, Nevers, and Orleans.[24]

By the dawn of the eighteenth century, Venice and other Italian cities long noted for the excellence of their glass were well on their way to a position of lesser importance. Continued emigration of skilled Italian artisans, discovery of resources peculiarly valuable in glassmaking, accumulated experience, and further improvement in the state of the art all account for the rise of France, Germany, and England as glass-manufacturing nations.

Bohemia appeared first as a superior competitor. Bounteously endowed with supplies of excellent glass sand, this country soon became noted for the quality of its crystal, which was strikingly white and far clearer than Venetian. The reputation of Bohemian crystal was further enhanced by a concurrent and truly

[23] Weeks, pp. 66–68.
[24] Schmidt, p. 402.

remarkable development of the techniques of glass cutting and engraving.[25] The despair of Muranese craftsmen of the seventeenth as well as the eighteenth century, Bohemian fine glassware maintained a position of superiority until the discovery and perfection of the English process of lead-glass production.

Bohemian craftsmen also appear in the seventeenth century to have shared with the workers in other localities, including the Venetians, superiority in window-glass production. In the eighteenth century Venice was surpassed. Despite the fact that France had been active in encouraging establishment of the glassmaking arts, she seems in the seventeenth and even in the early eighteenth centuries to have been somewhat inferior to Germany in window-glass manufacture. All her better window glass, it is said, then came from Germany and Bohemia.[26] But if France lagged in this branch of the art, she was in these periods laying the groundwork for her eighteenth- and nineteenth-century preëminence in plate-glass production. It will be recalled that Colbert in 1665 had brought a group of glass blowers from Murano; he established them first at Paris and later at Tour-la-ville, near Cherbourg. These workers made plate glass by blowing, the only method known at that time. In 1688, however, one of the workers, Thevart, rediscovered the ancient art of casting plates of glass.[27] He was rewarded by a thirty-year monopoly from the government, established extensive works at Paris, and succeeded in casting plates of the then astonishing size of 84 by 50 inches. The furnaces used by him were later moved to Saint-Gobain.

Glass Manufacture in England

In England glassmaking grew to significance later and more slowly than in the countries of the Continent. Bede, in his history of Wearmouth, reports that in 674 the abbot Benedict sent abroad for craftsmen to glaze the windows of the church and

[25] Weeks, p. 68.

[26] Weeks, p. 66.

[27] Jarves, 2nd ed., p. 28. Porter, following Handicquer de Blancourt's *De l'art de la verrerie,* reports accidental rediscovery of cast glass at the end of the fifteenth century (G. R. Porter, "Treatise on the Manufacture of Glass," in Dionysius Lardner, ed., *The Cabinet Cyclopaedia* [1832], p. 134).

monastery at Wearmouth and that these workers are to be credited with the beginning of window-glass manufacture in England.[28] If this be so, their efforts do not seem to have amounted to much; at least, no success of any magnitude is indicated in the records of immediately subsequent centuries. That crude objects serving primary needs were made at Surrey and Sussex at an early date is, however, well established. According to Powell glass manufacture there was considered of great antiquity in the sixteenth century, and supporting evidence in the form of maps, relics, and place names exist in abundance. The first authentic record of glassmaking in England is contained in a grant by Simon de Stocha, living in 1226, of twenty acres of land in Chiddingfold to Laurence the glassmaker.[29] This worker, reputedly the father of Wealden glassmaking, established himself at Dyers Cross near Pickhurst and built up a considerable business in clear and colored window glass. In 1240 he supplied glass of both types for a new abbey at Westminster.[30] A deed of 1280 for land in the area of Laurence Vitrearius' operations mentions an "oven-hus-veld" as a boundary. "This field has been identified and within its area fragments of fused glass and of broken crucibles have been discovered." [31] Another deed, of 1300, names one William, "le Verir," of Chiddingfold.[32] William, the son of Laurence, maintained activity at the glassworks at least to the end of the thirteenth century and helped secure a royal charter for Chiddingfold in 1300.[33]

Thorpe reports that another French family, the Schurterres, succeeded to the industry in the fourteenth century and ushered in the great period of Wealden production.[34] Much but not all of the output of these glassworks was for glazing purposes.[35]

[28] Porter, p. 134.
[29] Powell, pp. 10–11.
[30] Thorpe, p. 81.
[31] Powell, p. 11.
[32] Powell, p. 11.
[33] Thorpe, p. 81.
[34] Thorpe, p. 82.
[35] John Schurterre, glassmaker of Chiddingfold, died in 1378. His widow, arranging with one John Glaswryth to carry on the work in her behalf, required payment according to the amount of broad (window) glass produced and the number of vessels made. (Powell, p. 16.) At this time both hollow and window glass were turned out at Chiddingfold, at the same glasshouse.

Between 1350 and 1356 Alemayne [an agent for Chiddingfold glass] secured orders for some at least of the glass required for St. Stephen's Chapel, Westminster, and for St. George's Chapel at Windsor, while the Holmeres [agents, also] conveyed Wealden glass from Chiddingfold to Westminster. Another firm of agents, Dedington and Son, had their headquarters at Chiddingfold and supplied window glass for St. Stephen's Chapel, Westminster (1351), Merton College Chapel (1359), Winchester College, and New College (1386).[36]

Glass continued to come from the Schurterre furnaces up to the end of the fifteenth century. In 1435 these glassmakers were joined by a new group, the Poitous, who were still at work in the sixteenth century.[37]

Sometime before the middle of the fifteenth century a period of decline seems to have settled over the glasshouses of Chiddingfold and vicinity. One manifestation of this is to be found in a record of 1447 which reports that John Prudde of Westminster contracted to "use no glasse of England" in glazing the windows of Beauchamp Chapel at Warwick. If, indeed, English glass was falling in public esteem as early as this, one may surmise that the glass for the windows in the palace of Henry VIII, which constituted one of the attractions of the Field of the Cloth of Gold in 1520, was of foreign manufacture.[38] Thomas Charnock, writing in 1557, is also unenthusiastic about the English glass industry. He says:

> As for glass-makers, they be scant in the land;
> Yet one there is, as I do understand,
> And in Sussex is now his habitation;
> At Chiddingsfold he works of his occupation.[39]

About 1567 a group of foreign glassworkers began the manufacture of glass vessels in Crutched Friars. These men, under the leadership of John Carré, are said to have been the founders of the first permanent establishment for crystal glassmaking in

[36] Thorpe, p. 82.
[37] Thorpe, p. 82.
[38] Weeks, p. 68.
[39] Quoted in Weeks, p. 68.

England. To support his projects, Carré had applied for two patents of monopoly, one in window glass and one in drinking vessels. Successful only in securing a twenty-one-year license for the manufacture of window glass, Carré nevertheless carried out his plans for producing crystal glassware. The Lorraine and Normandy workers with whom he began operations, however, proved unsatisfactory and in 1571 it became necessary to replace them by a group of Venetians. Among the Venetian artisans was one Jacob Verzelini, "the pattern of all glassmakers and a great figure in . . . English industrial history." When Carré died in 1572 Verzelini assumed control of the venture Carré had begun. But the works in Crutched Friars burned in 1575, possibly at the hands of jealous London glass importers. To avoid further trouble Verzelini promptly applied for royal license. It was granted to him on December 15, 1575, and for the following twenty-one years he enjoyed the sole English right to make glass of the Venetian type.[40] Under Verzelini and his successors fine glassmaking became firmly established in England.

Carré's window-glass monopoly meanwhile seems to have fared only moderately well; it was, at least, on the defensive. In 1589 there is a petition from a George Longe requesting transfer of the Carré patent to himself. Longe contends that the terms of the earlier monopoly had not been fulfilled, that royalties had not been paid, that many glasshouses were at work without license, that the forests had been wasted, and that the art had not been taught to Englishmen. If he were granted the monopoly, Longe guaranteed among other things to reduce the total number of glasshouses then in England — fourteen or fifteen — to four, but he would erect others in Ireland to save English wood at the expense of Irish wood. We do not know whether Longe or another aspirant succeeded to the Carré patent, but it is likely that someone did, for monopoly licenses continued to be a favored technique of English industrial encouragement. Verzelini's crystal patent, for example, passed first to Sir Jerome Bowes, then to Sir P. Hart and Edward Forcett.[41]

[40] Thorpe, pp. 96–99.
[41] Powell, pp. 20–21, 31.

The Introduction of Coal Fuel

The year 1611 marks the beginning of a new era in English glass manufacture and indeed is an important milestone in the history of glassmaking generally. The era was inaugurated by the granting of a significantly new monopoly privilege, a patent for coal-burning glass furnaces. The potentialities of this innovation revealed themselves rapidly. In 1612 a monopoly was awarded for the manufacture of all kinds of glass by coal fuel. A year later an investigation of the quality of glass so made passed favorable judgment and within two years of that time the use of wood fuel in glass manufacture was forbidden by proclamation. In 1618, by way of climax, the entire interests of the glass monopoly were acquired by Sir Robert Mansell.[42] Mansell, "a Welshman with the manners of an admiral and the brain of a financier," exploited his privileges to the full and thereby altered fundamentally the character of English glass manufacture. "Sir Robert," says Thorpe, "organized the glass industry on a national scale, and from a purely industrial point of view he did it great benefits . . . He defined the main branches of the glass industry in the form in which we know them to-day." [43] Mansell made, to use his own words, "all manner of drinking glasses broade glasses [cylinder window glass] windowe glasses [crown window glass] looking glasses [the first definite evidence of the manufacture of mirror plate in England] and all other kinds of glasses, bugles [beads of black or dark green glass] bottles violls [vials] or vessels whatsoever made of glass of any fashion stuff matter or metal whatsoever . . ." [44]

Thorpe further describes Mansell's activities:

He developed the coal-mining industry on the Tyne for the service of local glasshouses, and from Newcastle and from Scotland he transported sea-coal for his London furnaces. There is little doubt that he encouraged the mining of "pit coal" in South Wales, his own home, in the Forest of Dean, and in Staffordshire. He imported barillia

[42] Powell, pp. 31–32.
[43] Thorpe, pp. 115–116.
[44] Quoted in Thorpe, pp. 115–116.

from the Mediterranean. He was the first of the glass magnates to bring Stourbridge clay into general use for making siege-pots, and he also imported clay from Spa (Germany), Paris, and Rouen. At Newcastle a local clay was used . . . During the period 1615–56 Mansell started or absorbed glasshouses at London, Greenwich, Lambeth, Newcastle-upon-Tyne, Swansea, Milford Haven, Newnham-on-Severn, Stourbridge, King's Lynn, Purbeck Island, the Trent Valley, and Wemyss in Fifeshire.[45]

Powell's evaluation of the consequences of the Mansell monopoly is selective and cautious. He says:

It is difficult to assess the advantages of Mansell's *régime*. The saving of timber consequent upon the universal adoption of coal for melting glass was an undoubted advantage. The community benefited by the establishment of window-glass and bottle factories in many parts of the country, where previously supplies of glass could only be obtained with difficulty. The monopoly may have equalized the quality of the glass throughout the country, but there is no proof that there was any special development of artistic craftsmanship.[46]

The Discovery of Lead Crystal

The seventeenth century also witnessed the second really important advance in glass manufacture of modern times, the development of lead glass. Prior to this innovation, from the days of antiquity, most objects and forms of glass had been shaped from a composition which had as basic constituents silica and soda or lime.[47] The development of lead glass involved the substitution of oxide of lead for carbonate of lime. The innovation has been attributed to the inspiration of several different English glassmakers, Powlden, Tilston, and George Ravenscroft among others.[48] Thorpe offers an explanation of the development that is of the greatest interest to students of industrial history and the inventive process. To him the innovation ap-

[45] Thorpe, p. 116.
[46] Powell, pp. 33–34.
[47] Weeks, pp. 30–33.
[48] Powell, p. 32.

pears to have been the consequence of a reciprocating action between industrial necessity and a particularly favorable milieu. "The agent of this achievement," he says, "was George Ravenscroft, who made the new metal a marketable commodity, but its real authors were the English scientist and the English shopkeeper." [49]

The years surrounding the birth date of lead crystal were years of keen and growing interest in the "extension of natural knowledge." After the incorporation of the Royal Society in 1662 this interest began to be directed toward specific industrial processes and glass manufacture was one of the first to benefit by it. The impact of the experimental movement on the glass trade is exemplified in the established fact that the names connected with the discovery of lead glass were closely associated with the new quest for scientific understanding. This group included Robert Boyle, Robert Plot, Dr. Ludwell, Houghton, and probably Ravenscroft himself. One of its most vigorous members was Dr. Christopher Merret, physician of London and translator of Neri's *L'arte vetraria,* the first textbook of glassmaking to appear in the English language.[50]

The temper of the times was highly conductive to inquiry, experiment, and change in the field of glass technology. That this circumstance, however, would of itself have had sufficient impetus to induce the commercial introduction of lead glass is open to serious question. For an explanation of the precipitation element in the discovery of lead glass, Thorpe turns our attention to the peculiar position and particular necessities with which the London Glass Sellers then found themselves confronted. Through out the first half of the seventeenth century the glassmakers of England and of northern Europe generally had been forgetting how to make as well as how to use the metal of Murano. The culmination of this process constituted the first of two problems facing the glass sellers. They found the quality of the metal from English furnaces something decidedly less

[49] Thorpe, p. 143. Cf. A. P. Usher, *A History of Mechanical Invention* (1929), especially chapters i and ii.

[50] Thorpe, p. 144.

than they wished to see incorporated in their stocks. In addition their requirements would not have been satisfied even if they had been able to obtain wares fashioned from the purest Murano, for during the period associated with the decline in quality of metal, style in glass had changed. And style in glass had changed because of the gradual transfer of glassware from a commodity of high luxury to one more generally and widely used. Once glassware had moved into the latter category, "a thicker, stronger, more durable ware" was needed. Indeed, it may be supposed that it was a groping search for a metal suited to this end that was partially responsible for the corruption of the standards of Murano. So it came about that London, under the guidance of the glass sellers, "spent the period 1660–75 in learning a substitute within her powers, and in fitting it for the needs of her market." [51]

Thorpe is very insistent on the point that the merchants of London not only clearly recognized the problems confronting them but also were directly and immediately responsible for the appearance of lead crystal. Their company, he says, was divided into two groups, the free traders and the prohibitionists. The free traders were content to continue the importation of Venetian wares. The prohibitionists, on the other hand, were anxious to obtain their merchandise from the home market; they were keenly aware of the "difficulty of co-ordination between retail in London and manufacture hundreds of miles away." The company, under constant pressure from the prohibitionists, was finally persuaded to investigate the possibility of developing and producing a suitable English glass. After some preliminaries the services of George Ravenscroft were engaged and after April, 1674, he conducted continued experiments in behalf of the glass sellers with men and facilities provided by the company. Success was achieved in the early months of 1676 and the company was rewarded for its effort and expense by exclusive reservation of the first supplies of true lead crystal. Ravenscroft's metal proved so desirable that within a very short time it became necessary to mark the new wares distinctively; the adoption of

[51] Thorpe, p. 136.

the device of a raven's head, impressed on each piece of glassware, constituted both a protective device and a graceful gesture of appreciation of Ravenscroft's contribution.[52]

The seventeenth-century invention of lead crystal may thus be regarded as a result of a process closely similar to twentieth-century practices — an expensive, conscious, sustained search under laboratory auspices for a solution to a pressing industrial problem. Thorpe clearly regards it in this way and takes care to stress the importance of the role played by the men of vision, the London Glass Sellers. The discovery of lead glass "was the result of an attempt, conceived deliberately and carried out experimentally, to provide a sound commercial substitute for 'rock crystal.' And in the whole history of glass it was a new thing . . . They [the London Glass Sellers] may be said to have defined the nature and function of retail in a sense applicable to other industrial arts and to other circumstances than theirs. They were artists because they were great shopkeepers." [53]

Without minimizing the achievements of either the London Glass Sellers or of Ravenscroft himself, and without necessarily contradicting the part that they played, it should be indicated that other men and other events may also have contributed significantly to the evolution of lead glass. Powell, for example, presents a thesis of its origin which is at once logical and consistent with what we know today of the evolutionary nature of the inventive process.[54] He believes the innovation to have been closely related to substitution of coal for wood fuel, itself an outgrowth of the exhaustion of English forests. The use of coal fuel soon demonstrated to glassmakers that it was advantageous to cover the melting pots when any of the ingredients necessary to the manufacture of the finer glasses were employed. If this was not done, the action of the coal fire deteriorated the "metal." But when pots were covered, considerable loss of heat occurred. Thus there ensued a search for a more easily fused formula. The solution was found to lie in the use of greater quantities of lead

[52] Thorpe, pp. 153–158.
[53] Thorpe, pp. 144–145, 152.
[54] Cf. Usher.

oxide. In this way, Powell believes, there gradually evolved the beautiful and lustrous glass in the use of which the English excelled.[55]

In considering the compatibility of Powell's general explanation and Thorpe's more specific account it is significant to note, first, that Ravenscroft's first experiments did not involve lead glass and were failures; second, that the use of lead as a glass flux is mentioned in Neri's *L'arte vetraria*, published in 1611; and third, that it proved necessary for Ravenscroft to *consult his friends* before success was achieved.[56] It is not impossible that in the course of these consultations, Ravenscroft drew the key to the solution of his problem from discussions of the melting practices to which Powell has reference.

By the end of the seventeenth century the glass industry of England had become well established, the number of glasshouses had increased significantly, and the basis of the subsequent strong position of England in the eighteenth and nineteenth centuries had been well laid. In 1589 Longe had reported the existence of but fourteen or fifteen enterprises. John Houghton in 1696 specifically lists and classifies eighty-eight.[57] In quality English lead glass "in so far as material determines process and design . . . set the development of two centuries. It put England at the top of the world market because it was more durable and useful than any metal previously produced." The English "drew out their own characteristics from a foreign and upstart trade and raised glass to be the equal of silver and cabinet-making, one of the great trio of industrial art in the time of Queen Anne." [58]

[55] Powell, pp. 31–32.
[56] Thorpe, pp. 155–157; Powell, p. 32.
[57] Powell, pp. 20, 21, 39.
[58] Thorpe, pp. 158, 163.

CHAPTER II

THE ART OF GLASSMAKING IN COLONIAL AMERICA

IN AMERICA the mysterious art of glassmaking was among the earliest of Colonial industrial enterprises.[1] Indeed, the early English venturers to the New World had scarcely set foot upon the shore before they turned their energies to production of the valued "white metal." [2] To these first colonists America doubtless appeared divinely prepared for the glassmaking arts. All about them stretched the fuel of the endless forests, and at their feet lay the sands of the sea. But despite the advantage of an early beginning and the abundance of certain essential resources, the history of glassmaking in the Colonial period is a chronicle of continuous failure. The hope and enthusiasm of the pioneer glass craftsmen soon dissipated in the face of the difficulties with which they found themselves confronted, and although recurring attempts at glass manufacture are recorded throughout the entire span of the Colonial period, one difficulty or another caused every attempt to be abandoned.

Several different but not always unrelated factors account for the continuous adversity which beset Colonial glassmaking. In the forefront of these must be placed the fact that American houses and households of the seventeenth and even the eighteenth centuries required and employed but little glass. This circumstance was in part a consequence of social custom and in part a manifestation of the essential requirements and problems of pioneer life. The seventeenth-century English houses which the colonists had left behind were neither universally nor elab-

[1] From earliest times the fashioning of shapes and forms from glass had been invested with a highly romantic cloak of legend and superstition. The glass blower was often classed with the alchemist, so great was the mystery attached to his art.

[2] See M. P. Hull, *Early Glass-Making in Virginia* (1933), *passim*.

orately furnished with glass windows. A continuance of this circumstance in the homes of the new land, therefore, was not counted a particularly pressing deficiency, especially when coupled with the realities of a rigorous and intermittently hostile land. The use of glass within the Colonial household was even more limited than its incorporation in Colonial buildings.[3] Here too ancient practices of the mother country coincided with the requirements and resources of the new land. Table furnishings, for example, in many if not the majority of early Colonial households were fashioned from wood. Wooden plates, vessels, and containers were not only cheap, durable, and convenient but were quickly and easily replaced. With the passing of the more primitive phases of the Colonial period, pewter and related metals came into vogue on the dining tables of the more affluent homes. But wooden service remained common in the back country and in the poorer homes for a surprisingly long period. Glass products of the seventeenth and eighteenth centuries were indeed less expensive than those fashioned earlier, but their prices were still high enough to be unattractive to the average householder — especially the average householder of the New World who found within easy reach less elegant but no less effective substitutes.

Neither the nature and necessities of pioneer life nor the usages and conventions of social custom, however, constitute the full explanation of the failure of Colonial glassmaking. A certain amount of glass was both desired and obtained by the colonists. In the eighteenth century its use increased, particularly in the more prosperous and cosmopolitan coastal areas. That so little of the glass consumed came from domestic furnaces is further explained by the strong position of the English glass industry; British determination to retain the colonies as sources of raw materials and markets for finished products; prejudice in favor of British goods, especially among those colonists best able to purchase glass; the technical difficulties of adapting

[3] The unimportant place of glass in both houses and households is consistently reported in the numerous and diverse sources of information upon manners and customs of the Colonial period; memoirs, accounts of travel, correspondence, court proceedings, village, town, and personal histories, and official documents all testify directly or indirectly to the same fact.

American resources to the routine of English glass practice; and the high cost and scarcity of the type of labor essential to successful production of glass. Among these factors none was more important than the deficiency in labor supply. In few other crafts of the seventeenth and eighteenth centuries were skill and experience of greater significance than in glassmaking. Colonial America possessed a quantity and quality of workers wholly inadequate to the establishment of a permanent domestic industry. To this circumstance British policy was a contributor, but it must also be borne in mind that the vigor of the English glass industry in the late seventeenth and eighteenth centuries, its improving competitive status, and the consequent attractive opportunities at home would in any event have reduced substantially the migration of English glassworkers to America.

The details of the history of Colonial glassmaking are obscured by the uncertainty inevitably associated with fragmentary records. It is, however, clearly established that glasshouses were erected in Virginia, New York, Massachusetts, and Pennsylvania soon after colonization. The Virginia glass-manufacturing venture in 1608 or 1609 was part of a comprehensive program designed to generate immediate pecuniary gains from this colonial settlement.[4] Of the New York and Pennsylvania works little is known. The former was built early in the seventeenth century on the southern end of Manhattan Island.[5] The existence of the latter is recorded in a letter written by William Penn in 1683.[6] The first glasshouse in Massachusetts, built at Salem about 1634, seems to have had a somewhat longer period of activity than those in neighboring colonies. The records clearly indicate at least intermittent activity until 1645 and imply continued operation for several years after that date.[7]

[4] The vessel which carried Captain Newport to America on his second voyage in 1608 brought eight Poles and Germans to make "pitch, tar, glass, mills and soap-ashes" (J. L. Bishop, *A History of American Manufactures from 1608 to 1860* [1864], I, 25). For recent research concerning this attempt see Hull.

[5] Weeks, p. 93; E. A. Barber, *American Glassware Old and New* (1900), p. 12.

[6] Weeks, p. 79.

[7] J. B. Felt, *Annals of Salem* (1827), pp. 152–153; V. S. Clark, *History of Manufactures in the United States* (1929), I, 152. Clark says production continued until 1670 when the works were abandoned "for lack of capital."

For more than fifty years subsequent to the latest of these early attempts at glass manufacture there is scant evidence of domestic production.[8] Either the colonists had become thoroughly discouraged by initial failures or our records are peculiarly deficient for this interval. Only in the quarter century preceding the Revolution are there indications of a further attempt to construct and operate domestic glass furnaces. By that time increasing wealth and prosperity leading to an increase in the consumption of glass manufactures had strengthened the financial prospects of the industry. The years immediately preceding the Revolution also afforded a further incentive, patriotic in inspiration although pecuniary in effect. In 1767 Townshend's scheme for raising revenue from the American colonies was met by strong denunciation soon followed by agreements for non-importation. When public meetings had crystallized resentment and when a decision was reached to promote domestic industry by all prudent means, glass, one of the taxed commodities, was mentioned as an industry especially deserving encouragement.[9] Although the Townshend Acts were repealed in 1770, the clear threat contained in the repealing statute further augmented the desire of the colonists for domestic industries.[10] Consequently this period, and particularly its later years, witnessed the construction of glasshouses in Massachusetts, Connecticut, New York, New Jersey, and Pennsylvania. Not only were new glasshouses built, but the range of articles produced by the furnaces was extended. Whereas the furnaces of the seventeenth century produced in all probability only bottles, beads, certain other crude objects for immediate local use, and perhaps some window glass, at least two of the houses established shortly before the Revolution undertook not only extensive output of window glass but the manufacture of fine flint (lead) glassware as well.[11] Not until Henry William Stiegel began his activities was lead glass

[8] Weeks, pp. 77–98.

[9] Weeks, p. 80.

[10] Bishop, I, 237.

[11] Weeks, pp. 77–98; Bishop, I, 232–243; Barber, pp. 13, 37. These works, built by Stiegel and Wistar, produced glass of considerable artistic merit, much prized by antiquarians of today.

produced in America,[12] nor was any significant quantity of glazing glass forthcoming prior to this time.[13] For reasons already given such conditions were to be expected. This held particularly true of fine flint glassware, which required in both melting and forming a degree of skill notably higher than in the fabrication of the coarser household wares.

Despite the stimuli of the pre-Revolutionary period and the fact that several of the attempts at glassmaking were more ambitious and longer-lived than their forerunners, the Revolution closed another chapter in the long chronicle of failure. By the time the war was well under way, American glass manufacture was practically nonexistent.[14] By 1780, however, glass was in brisk demand. English imports had been cut off when the mother country prohibited exports, and imports from other

[12] Stiegel, who possessed both artistic skill and means, was ostentatious in his projects. He erected a castle mounted with cannon whose discharge announced his arrival and in baronial style summoned his workmen from furnace and foundry. (Bishop, I, 238.) See also F. W. Hunter, ed., *Stiegel Glass* (1914); G. L. Heiges, *Henry William Stiegel* (1937).

[13] Jarves, 2nd ed., pp. 54–55. Jarves's book is the most valuable single work on early American glassmaking. Jarves was an influential figure in the development of the industry in the early nineteenth century. He was agent, or general manager, for the New England Glass Company and was later closely identified with the famous Sandwich works.

Most if not all of the diamond-shaped panes used in seventeenth-century Colonial dwellings were brought or imported from England. In the early years of the century, prospective colonists had been advised to bring window glass with them. (Bishop, I, 234–235.) In 1689 Holme characterized the economic status of window glass as follows (Weeks, p. 79):

"The window-glass is often here
Exceeding scarce and very dear,
So that some in this way do take
Isinglass windows for to make."

[14] In 1763 Governor Bernard of Massachusetts commented that "nails, glass, lead, locks, hinges, and many other materials for houses are wholly imported from Great Britain." In making a report to the Board of Trade in 1766 and 1768 he mentioned the failure of a glass factory conducted by German Protestants at Germantown in the town of Quincy. (Clark, I, 208.) Stiegel failed in 1774, Wistar in 1775, the Stenger Works at Glassborough, New Jersey, in 1780–81. The Connecticut attempt, or attempts, were all failures before the Revolution. Governor Moore, in a letter to the Lords of Trade and Plantations dated Fort George, New York, January 12, 1767, said: "The Master of a Glass House, which was set up here a few years ago, [is] now Bankrupt." (Weeks, pp. 93, 95.)

countries had been excluded by the blockade, for runners had little space for so bulky a commodity as glass.[15] Even under these circumstances, few glassworks sprang up during the years of strife; those that did suffered heavily from the wave of imports that followed the return of peace.[16]

[15] W. Hill, *First Stages of the Tariff Policy of the United States* (1893), p. 39; Weeks, p. 91.

[16] Hill, pp. 59, 64–66.

CHAPTER III

GLASSMAKING IN THE UNITED STATES, 1789–1820

FOR SEVERAL YEARS after 1783 the intense demand for foreign commodities operated as a strong deterrent to the construction of glassworks in the United States. The absence of anything that could have been described as an established glass industry is attested in part by the tariffs of two states which later became important in glass manufacture. The Pennsylvania act of September 20, 1785, imposed high specific duties on more than forty articles which that state had begun to manufacture. Many other imports were made subject to a duty of 10 per cent ad valorem. In contrast, however, "all panes, plates, vessels and utensils of British glass" carried merely 2½ per cent, obviously an imposition for revenue. In 1786 Massachusetts passed an act prohibiting the importation of articles which formerly had been taxed at the highest rates and which the home industries were then supplying in sufficient quantities. It is noteworthy that glass products were not included among the prohibited items.[1]

Between 1786 and 1800 glassmaking was begun in Massachusetts, Connecticut, Maryland, Virginia, New York, western Pennsylvania, and possibly elsewhere.[2] This period constitutes the first phase of substantial progress in the development of the glass industry in the United States; its accomplishments laid the foundation for the permanent establishment of the industry. Four outstanding events characterize the period: an increasing number of glasshouses, a broadening of the range of products,

[1] Hill, pp. 148, 51, 150; *Acts and Laws of the Commonwealth of Massachusetts, 1786–87,* c. 48 (1893), pp. 117, 122. Imports of glass by this act were made dutiable at 15 per cent ad valorem, however.

[2] Weeks, pp. 77–98.

the founding of the first firms operating with a degree of success sufficient to permit continuous production for more than a few years, the first production of glass west of the Alleghenies.

By 1800 five glassworks are known to have been in operation — one each in New York, New Jersey, and Massachusetts, and two in Pennsylvania. An additional three works probably were active and still another three or four may have been, although it is doubtful.[3] Thus a rough estimate of the total number of American glasshouses at the beginning of the nineteenth century would indicate eleven or twelve as a maximum and five as a minimum. These works produced window glass, bottles and other common glassware, and flint glass. Window glass in comparison with earlier years now bulked large, bottles and common glassware were produced in moderate amounts, but flint remained unimportant.[4] As suggested elsewhere, domestic production of common glass traced its history from the seventeenth century but the production of flint glass had been seldom attempted.

Three widely dispersed firms may be taken as representative of the first era of success in domestic glass manufacture. The first, located at Boston and later incorporated as the Boston Glass Manufactory, had been granted exclusive right of glass manufacture by the state of Massachusetts in 1787.[5] This privilege, valid for fifteen years, was reinforced by the threat of a fine of £500 for infringement.[6] As an added inducement to the Boston company, its capital stock was exempted from all taxes and its workmen were relieved of military duties.[7] Furthermore, to counteract the bounty paid by England on the exportation of glass, the state paid the proprietors a bounty on every table of glass made.[8] This action by Massachusetts was only one, though apparently the most successful, of many governmental attempts

[3] Weeks, pp. 77–98; Bishop, I, 232–243; W. S. Walbridge, *American Bottles Old and New* (1920), pp. 15–16.

[4] It seems likely that only one firm, the Hamilton Manufacturing Company in New York, was making flint at this time (Weeks, p. 94; Bishop, I, 241).

[5] Bishop, I, 241; *Senate Documents, 1823–24,* No. 45, 18 Cong., 1 Sess., p. 24.

[6] £500 according to Bishop and Weeks, but according to Jarves $500; in either case sufficient to be an effective deterrent.

[7] Weeks, p. 89; Bishop, I, 241.

[8] Jarves, 2nd ed., p. 56.

before 1800 to assist in the establishment of a domestic glass industry.[9]

The furnaces of the Boston company produced crown glass of good quality at least until 1822.[10] Jarves has pointed out the significance of its success: "From the founding of this establishment may be dated the founding of all the Crown and Cylinder, Window and Flint Glass-Works in the Atlantic States. Indeed, this may be considered the fruitful parent tree of the many branches now so widely spread abroad." [11]

The Hamilton Manufacturing Company supplies another example of successful glassworks built between 1786 and 1800. About 1792 new proprietors took over a glasshouse that had been established near Albany a few years earlier. In 1796, for

[9] One of the instances of governmental assistance extended to the glass industry is recorded in the seventeenth century and the others in the middle and late years of the eighteenth. From 1786 to 1800 there are many examples (Weeks, p. 92). In 1639 and again in 1640 the town of Salem awarded a quantity of land for the encouragement of glassmaking. For the benefit of the same enterprise the General Court of Massachusetts in 1641 authorized the town of Salem to extend to the "Glass men a loan of £30 to be deducted from the next town rate." (Felt, pp. 152–153.) Connecticut in 1747 gave Thomas Darling the exclusive privilege of glassmaking and later made similar grants to others for the same purpose. In 1752 the General Court of Massachusetts also granted certain individuals a monopoly of glass manufacture. A lottery authorized by the New Hampshire Legislature was held in 1781 for the benefit of a glassworks at Temple. (Weeks, pp. 89, 92, 94.) Two years later in consideration of valuable services during the Revolution Connecticut awarded exclusive rights of glass manufacture to the Pitkin family. John Frederick Amelung of Maryland endeavored to enlist the aid of the federal government in 1790. Previously Maryland had given evidence of its willingness to foster the domestic industry by a loan of considerable proportions. (Bishop, I, 243.) Although the Amelung petition was favorably reported by committee, which recommended a loan of $8,000, Congress voted adversely on the proposed subsidy. (Weeks, p. 95; *American State Papers: Finance,* [1832], I, 62.) In 1793 the New York Legislature voted a loan of £3,000 to a glassworks, providing no interest charge for three years and 5 per cent for five more. Three years later the same legislature issued a charter for glass manufacture and incorporated in it a provision exempting the company and workmen from taxation for five years. (Joel Munsell, *Annals of Albany* [1854], III, 167, 177.)

[10] Jarves, 2nd ed., p. 56. Jarves speaks somewhat ambiguously. He says the company made "a glass superior to the imported, and well-known throughout the United States as 'Boston Window-Glass.' This reputation they steadily sustained, until they made glass in their new works at South Boston, in the year 1822."

[11] Jarves, p. 56.

the purpose of consolidating and extending operations, a village ten miles west of Albany was laid out and named Hamilton, and in the spring of 1797 the Hamilton Manufacturing Company was chartered by the state. The New York Legislature aided the enterprise by exempting company and workmen from taxes for five years. This works became one of the most extensive in the United States. It operated two glasshouses with three large furnaces, employed thirteen glass blowers, and produced 20,000 feet of window glass per month, plus a quantity of bottles and flint glass. Its glass came to be highly prized and the furnaces continued active until the fuel supply became depleted in 1815.[12]

The erection of the Craig and O'Hara glassworks at Pittsburgh in 1797 furnishes a third illustration of the founding of successful enterprises. It also marks the first glassmaking venture west of the Alleghenies.[13] Pittsburgh's first glasshouse successfully produced window glass and bottles well into the nineteenth century, yet unlike the Boston and New York enterprises it received no governmental assistance. It maintained its position because it enjoyed the benefit of good location and certain other important manufacturing and commercial advantages. It is significant that the first factory in the future center of glass manufacture in the United States was relatively prosperous shortly after raw materials had been placed in the first pots.

If the achievements of the closing years of the eighteenth century may be said to have laid a prophetic though skeletonized foundation for later growth of domestic glass production, clearly the circumstances of the next twenty years hastened the reinforcement of this foundation and the erection of a superstructure upon it. The period preceding the events which led to the War of 1812 witnessed a process of slow but appreciable development. Records indicate not only that most of the furnaces erected just prior to 1800 continued operations but that several new ones were built in Massachusetts, New York, and Pennsylvania.[14] The events and circumstances of the period of restricted

[12] Munsell, II, 205; III, 156, 167, 170, 177; IV, 231; V, 307; X, 219–220.

[13] Weeks, pp. 83–85.

[14] Weeks, pp. 77–98; Bishop, I, 232–243; Jarves, 2nd ed., pp. 55–60, 67–73, *passim;* Jedidiah Morse, *The American Universal Geography* (1805), Part I, pp. 384, 441, 490, 519, 545, 601.

imports, 1808 to 1814, provided new and highly effective stimuli. All types of domestic industry benefited but particularly glass manufacture.[15] Even before war was declared new capital was moving into the glass industry, and we therefore find evidence of still more construction in states already identified with glassmaking, New York, Pennsylvania, and Massachusetts.[16]

The position of the new industry is revealed in the first national survey of manufactures. Although not dependable, the Census of 1810 is nevertheless valuable as the earliest statistical appraisal of the glass industry in the United States.[17] It revealed that domestic glassworks were more numerous and productive than had been supposed.[18] The census tables list twenty-two glassmaking establishments: one in Massachusetts,[19] two in Connecticut, four in New York, four in New Jersey, seven in Pennsylvania, three in Maryland, and one in the District of Columbia.[20] The census itself gives no single figure for value of total output, but if we value a large quantity of window glass at the marshals' estimate of average prices, the approximate total proves to be something over $1,000,000,[21] a figure whose magnitude is indicative of the expansion of the industry. Yet the constituent elements of this total are even more informative. Window glass represented more than four-fifths of the total; common glassware (including bottles) accounted for the great portion of the remainder; and flint was still produced in insignificant quantities.[22]

After 1810 the effect of the protective legislation which began in 1808 became more pronounced.[23] Tench Coxe pointed

[15] F. W. Taussig, *Tariff History of the United States,* 7th ed. (1923), p. 17.

[16] Weeks, pp. 77–98.

[17] See Adam Seybert, *Statistical Annals of the United States of America* (1818).

[18] *American State Papers: Finance* (1832), II, 685.

[19] The Chelmsford works which operated from 1802 to 1827 or 1828 apparently was omitted (Weeks, p. 90).

[20] U.S Treasury Department, *A Statement of the Arts and Manufactures of the United States of America* by Tench Coxe (1814). One glass-cutting establishment in Pennsylvania is also recorded.

[21] $1,046,000.

[22] Flint glass was produced at Boston, Pittsburgh, Hamilton, New York, and possibly, though not probably, elsewhere in small quantities.

[23] Taussig, p. 17.

out that whereas the industry had up to this time made considerable but slow progress, its rate of expansion was now greatly accelerated; in response to the new conditions new furnaces were built and fired.[24] In the latter part of 1810, for example, New York state alone had no less than ten glassworks either in operation, under construction, or in contemplation. The growing enthusiasm for glassmaking, however, called forth a warning from at least one contemporary. In his *Private Canal Journal* DeWitt Clinton said: "We entered the town of Vernon, in which three glasshouses are in contemplation; one has been in operation some time. It is rather to be regretted that this business is overdone. Besides the glass introduced from Pittsburgh, and from a glasshouse in Pennsylvania, on the borders of Orange County, and the glass imported from Europe, there are ten manufactures in the state already, or about to be established." [25]

A further indication of the magnitude of the expansion during the restrictive period is found in the production figures for the Pittsburgh area. The Census of 1810 reported total value of output in that locality as $62,000. By 1815 this had nearly quadrupled; value of products was then said to be $235,000.[26] More direct evidence of expansion, however, is contained in the statistics of incorporation from 1800 to 1820. Of the corporate bodies created for the manufacture of glass within this period none is recorded earlier than 1809. In that year three companies were incorporated in New York, one in Massachusetts, and one in New Hampshire. Six companies were created in 1810, New York being responsible for five and Vermont one. Four new firms in New York proved to be the only additions in 1811, but in 1812 and 1813 two more companies were undertaken, one in Massachusetts and one in New York. Massachusetts with three companies and New Hampshire and New York with one each, brought the increase in companies in 1814 to five. In 1815

[24] U.S. Treasury Department, *A Statement of the Arts and Manufactures . . .*, p. xliv.

[25] W. W. Campbell, *Life and Writings of DeWitt Clinton, Private Canal Journal* (1849), p. 191.

[26] Philadelphia Society for the Promotion of National Industry, *Addresses*, p. 257, cited in Weeks, p. 87. I have been unable to discover the edition of the *Addresses* which contains the information attributed to this source by Weeks.

there was but a single addition, in Massachusetts, and no more were chartered until 1820 when a large concern was incorporated by the state of Connecticut. Enterprises launched in corporate form between 1809 and 1815 thus totaled twenty-three capitalized at more than $2,270,000;[27] of these enterprises twelve with a capitalization of $1,160,000 were chartered between 1811 and 1815.[28] This record probably does not constitute a complete statement of the expansion; no account whatever is taken of firms beginning under individual proprietorship or partnership forms.

The end of the war not only put an end to rapid expansion of the glass industry but also brought distress to many of the glasshouses that had recently begun operations. When peace was made, the long pent-up stream of English manufactures flooded the country.[29] The sum of greatly increased imports and expanded domestic production was now greater than normal consumption capacity. Accordingly, prices of all manufactured goods declined sharply. A contemporary source reported that "the flint-glass, formerly made in Pittsburgh . . . amounted to upwards of 130 thousand dollars per annum. *The enormous influx of foreign glass has already stopped one of the furnaces, and reduced the manufacture about thirty thousand dollars a year.*"[30] As a result of the general depression only a few new glasshouses were built in the years preceding the crisis of 1819. There are records of two in New Jersey and one each in New Hampshire, New York, and Massachusetts.[31] Of these, the Massachusetts glasshouse was easily the most important to the development of the glass industry; in 1817 the now famous New England Glass Company purchased the works of the unsuccessful Porcelain and Glass Manufacturing Company and entered upon a long and highly successful career.[32] In general,

[27] One is listed as "unlimited."

[28] *Senate Documents, 1823–24,* No. 45, 18 Cong., 1 Sess.

[29] Taussig, p. 20.

[30] Philadelphia Society for the Promotion of National Industry, *Addresses* (Philadelphia: M. Carey, 1819), pp. 241, 242.

[31] Weeks, pp. 91, 92, 94, 96; Jarves, 2nd ed., p. 61.

[32] Jarves, 2nd ed., p. 61; L. W. Watkins, *Cambridge Glass, 1818–1888* (1930), p. 7.

however, the years following the peace were years of depression; by 1820 foreign imports, low prices, and general depression had brought about a period of pause in the progress of the glass industry in the United States.[33]

[33] According to a memorial adopted at a town meeting and sent to Congress in 1819, the manufacture of glass at Pittsburgh had declined rapidly after 1815. In 1815 there were 169 workmen employed and $235,000 in value of glass was produced annually, while in 1819 the number of workmen had fallen to forty and the value to $35,100. Flint glass alone had declined by $75,000. (Weeks, p. 87.) See also T. W. Dyott, *An Exposition of the System of Moral and Mental Labor Established at the Glass Factory at Dyottville* (1833). Dyott says (p. 15), "After the conclusion of the Treaty of Peace . . . they [glass factories] were compelled to suspend business, owing to the importation of the foreign article, which was designedly sacrificed at auction by the British agents, who publicly acknowledged at the time that they were instructed to sell at any prices, for the purpose of breaking up our factories."

CHAPTER IV

A VIEW OF THE AMERICAN GLASS INDUSTRY IN 1820

THE YEAR 1820 provides both a logical and a convenient point for a general description of the early glass industry of the United States. The art of glass had by this time become permanently established in America. The difficulties of the tentative and experimental stages that inevitably characterize the introduction of any new manufacture had been weathered and left behind. The industry, moreover, had not only won a place for itself in the country's youthful industrial pattern; it had also experienced a period of considerable prosperity and expansion. And immediately thereafter it had been exposed to severe foreign competition. By 1820, therefore, we find revealed not only the industry's strength, energy, and capacity for growth, but likewise its weaknesses.

The year 1820 is a convenient point of critical appraisal for still another reason. In that year or shortly after statistical and factual information becomes more abundant than before. The Census of 1820, although admittedly incomplete and not always accurate, nevertheless supplies us with valuable data of the glass industry — data more detailed, and hence more informative, than those presented in the preceding census. Furthermore, because the Census of 1820 was a second census of manufactures it affords a basis for statistical comparison which provides an at least partially accurate measure of the growth of domestic production. Still more important is the fact that systematic reporting of imports and exports of the United States begins at this time. From these data we may describe with some precision such important characteristics of the industry as the relative share of domestic production in total consumption, the amount of total imports, and the nature and amount of particular imports.

Production

In 1820 expansion of domestic glass manufacture had been halted. In the eyes of contemporary producers the condition of the industry appeared highly uncertain and forbidding; this uncertainty is shown in the census returns of 1820, many of which carried comments on the prospects of the industry. Two-thirds of the reporting glassworks mentioned the depressed state of glassmaking, and the proportion probably would have been greater had not almost a third of the nation's firms failed to comment. Thirteen establishments reported conditions dull, four admitted that their plants were declining, three indicated part-time operation, and one confessed complete inactivity. Only two said they were doing well. The following comments are typical: "Demand dull"; "Good business during last war but now embarrassing; sales dull"; "Glass in little or no demand"; "Not in full operation for want of a market"; "Formerly eight months in blast, now only three"; "Don't pay cost"; "Declining"; "In a depressed state"; "Condition rendered languishing by foreign importations"; "Sales dull, prices low"; "Languishing; supply overrunning demand due to large foreign importations." [1] Other contemporary records testify to the unsatisfactory condition of the glass industry at this time. Niles, Carey, and Dyott, for example, all declare the difficulties of the day.[2]

The effect on the glass industry of general depression and large foreign importations is apparent in the data of domestic production supplied by the Census of 1820. The total of values of output listed in the tables is $601,730.[3] Six reporting firms, however, gave no figure for value of output; four of these were window-glass factories and two produced common glassware. The data for one of these firms may be drawn from another source,[4] but it is necessary to estimate the proper additions

[1] *Digest of Manufacturing Establishments in the United States, American State Papers: Finance* (1858), IV, 29; hereafter cited as *Fourth Census.*

[2] *Niles' Weekly Register,* XVI, 404; Philadelphia Society for the Promotion of National Industry, *Addresses* (1819), *passim;* Dyott, p. 15.

[3] *Fourth Census.*

[4] Wilkes Allen, *History of Chelmsford* (1820), p. 75.

for the remaining five.[5] If this is done, total domestic production in 1820 may be set at approximately $788,000, a figure which represents an appreciable decrease from the $1,000,000 total of 1810. Part of this decreased total may be attributable to omissions of the census, although the greater portion undoubtedly arises from lower prices and less than capacity operation of domestic glasshouses. Some idea of the extent of the influence of these lower prices can be derived from the data for window glass. The census tables provide sufficient information for a rough approximation of the value of window glass produced in 1820.[6] Using this and the window-glass prices occasionally mentioned in the tables, the quantity of window glass produced may be estimated at 5,400,000 square feet, compared with 4,967,000 in 1810. The value of window glass in the latter year was $794,720 and in 1820 was $547,980. It is reasonable to suppose that prices of common glassware as well as flint moved similarly to window-glass prices.[7] We may therefore conclude that although the value of glass produced in 1820 was less than the figure for 1810, the quantity of glass manufactured under the depressed conditions of 1820 was greater than in 1810.

Glass factories reported in the first census of manufactures numbered twenty-two and at least twelve new glass enterprises were projected between 1811 and 1820. The figure given in the second census is thirty-four, which oddly enough is the exact sum of the number existing in 1810 plus the number incorporated in the succeeding decade. This of course is coincidence, since some firms must have begun operations between 1810 and

[5] Estimates are based upon values of output reported in 1810, or values of output of firms of similar size.

[6] It is necessary to estimate value of output for four window-glass works. These are based upon values of output reported in 1810, or values of output of firms of similar size. Also, three-quarters of the total value of products of firms producing both window glass and hollow ware is allocated to window-glass production. The percentage of estimated value to total value is low and hence the net figure is probably close to the fact.

[7] All types of firms mentioned low prices in the 1820 census comments. There is no suggestion of any contrary movement. It is possible, however, that the range of decline differed between the various branches of glass manufacture.

1820 under noncorporate forms of organization, and no doubt a number of failures or terminations occurred of which we have no record.

The nature and relative amounts of glass products made in the United States in 1820 were similar to the nature and amounts of 1810. Window glass was the product of greatest importance, representing almost 70 per cent of the total value of glass made, a condition not unexpected in an expanding country where building was taking place at a rapid rate. The estimated 5,400,000 square feet attributable to domestic manufacture constituted 89 per cent of the total window glass consumed.[8] At this time glazing glass was fashioned by two processes. Crown window glass was still being blown at Boston,[9] and possibly elsewhere.[10] But most glassworks were producing by the cylinder method, the advantage in quality of crown glass being more than offset by the superiority of the cylinder method in sizes and costs.[11] Of the twenty-three factories producing window glass not more than two or three still used the older process.

Two other broad classes of glassware being produced in America in 1820 were flint glass and common, bottle, or green glassware. The inclusive figures of the census tables do not permit any precise statement of the value or quantity of production of common glassware. Six firms are reported making bottle and common glassware, with a combined value of product of $81,850. To this figure must be added the amount of common glassware produced incidentally in window-glass factories; the census lists four establishments producing window glass and hollow ware with an output value of $125,800. Although the greater part of this total is attributable to window glass and although the precise proportion is not known, an allocation of

[8] In 1820 imports of window glass were 627,100 sq. ft. See Table 1.

[9] The high quality of Boston crown glass was responsible for the reputation enjoyed by "Boston window glass." It is consistently reported as better than the imported, even better than the finest Scotch. See, for example, *Niles' Weekly Register,* IX, 382; XVI, 404.

[10] The crown works in Oneida County, New York, is reported out of operation in the Census of 1820.

[11] A. E. Fowle, *Flat Glass* (1924), p. 31.

three-fourths to window glass and one-fourth to common glass may be taken as roughly accurate. Adding this to the former figure we derive a total of $113,300.

Many products were included under the general classification of common glassware: bottles of all sizes and for various purposes; white,[12] green, amber, and other colored glass; vials and apothecaries' "furniture" of all types; jars, retorts, and snuff-boxes; decanters, tumblers, and common tableware; and globes, chimneys, lamps, shades, and other articles. There is of course no information in this early period defining precisely the proportions in which these various articles were produced. It is highly probable, however, that bottles of all shapes, sizes, and colors formed a large part of the total. Vials and other apothecary equipment constituted a particularly attractive branch of bottle manufacture because of continuing high import prices.[13] Tableware of green glass was in common use, particularly in the less wealthy households.[14]

The extent of imports of common glassware is not known. Excluding window glass and black quart bottles, the total of foreign glass brought into the United States in the year ending September 30, 1821, was $240,000.[15] This figure cannot be broken down, and hence we can only point out that imports of glass other than window glass and black quart bottles were about the same as domestic production of glass other than window glass. This fact, however, justifies the conclusion that domestic production of flint and common glass constituted slightly more than 50 per cent of the total consumption of these articles, because the import figure of $240,000 included glass

[12] This white glass was not flint glass; the former was made from raw materials or "batch" similar to that used for window glass (Watkins, p. 62).

[13] Dyott, p. 15.

[14] Weeks, p. 86, quoting a letter from Mr. Isaac Craig, of the Craig and O'Hara works at Pittsburgh: "I recollect distinctly seeing both tumblers and decanters made of green glass. In old times decanters were used in every house, most commonly by the poorer families, who could not afford cut glass. Whiskey was set out to every visitor in these decanters, and before and after every meal. Although of green glass, they were not cut, but ornamented by beads around the neck."

[15] U.S. Treasury Department, *Commerce and Navigation of the United States, 1821* (1822); hereafter cited as *Commerce and Navigation.*

not contained within these two types — plate glass, for example, as well as looking glasses and glass novelties.[16]

Domestic production of flint glassware totaled less than $127,000 in 1820.[17] According to the census tables five firms devoted some or all of their pots to this product. The famous New England Glass Company at East Cambridge, Massachusetts, led in this kind of manufacture, producing an amount equal to half the total output and three times as large as the output of any other maker. Flint production at Pittsburgh is reported at only $20,000. Other works producing flint existed in Philadelphia County, Pennsylvania, and Wellsburg, West Virginia, while a very small works was located in Muskingum County, Ohio. The range of flint products being made at this time is exemplified by contemporary advertisements of the New England Glass Company. They include among other products apothecary and chemical wares; electrical apparatus; lamps, clock faces, and candle shades; globes of all sizes and kinds; decanters, tumblers, wine glasses, dishes, plates, and salts; barometer and thermometer tubes; carriage, picture-frame, and watch glasses.[18] Some years after 1820 the Wellsburg works was reported to be making glass decanters "of great beauty and solidity," and white flint glass rivaling the foreign product.[19] As in the case of common glassware, it is impossible to compute the proportion of total consumption made in America. Because

[16] The last three types of glassware, however, probably were imported in relatively small quantities. The deductive estimate in the text is confirmed by the comments of Dyott, p. 15, and *American State Papers: Finance* (1834), III, 85. In the latter domestic industries are divided into classes according to the proportion of their production to total consumption. Class I, comprising firmly and permanently established industries which wholly or almost wholly supply the demand for domestic consumption, includes window glass. Class III, listing industries which are so slightly cultivated as to leave the demand of the country wholly or almost wholly in the hands of foreign sources, includes glass of all descriptions except window glass and "phials."

[17] $127,200 is the total output of factories listed as producing flint or flint and other types of glass. Hence the total of flint alone could not have been more than this figure and actually was less; how much so it is impossible to say. The New England Glass Company, for example, made their products from either flint or window glass according to order. See Watkins, p. 62.

[18] Watkins, p. 62.

[19] Weeks, p. 78.

of the greater relative expense of flint, especially when it was ornamented by cutting, consumption in the United States was comparatively small.[20] The general tone of contemporary documents and statistics of imports for years subsequent to 1821 indicate that domestic production was considerably less than half of the total consumption.

In general the quality of domestic glass products was inferior to those imported, an expected condition for so youthful an industry. Certain exceptions should be made, however, notably for Boston crown glass and certain of the flint products of the East Cambridge and Pittsburgh works. Despite the variety of articles produced by the American glass industry in 1820 the manufacture of certain types of glass, plate for example, had not yet been attempted; the demand for these was completely satisfied by foreign products.[21]

Localization

The same factors that determined the sites chosen for the glasshouses of antiquity set the localization pattern for glassmaking in America. Glass in most of its commercial forms is a compound of silica and one or more of such bases as lime, potash, soda, and oxide of lead. Certain purifying elements or coloring materials may also be added. Silica, however, is quantitatively the most important direct ingredient. Its proportion varies from about 50 to 75 per cent, depending on the type of glass to be made. Next in order come the various bases which singly or in combination account for almost all of the remaining percentage. The proportion of coloring and purifying materials is usually very small. To melt glassmaking ingredients, very high temperatures are required and they must be maintained for long periods before the batch is ready for working. Glass manufacture has thus always required prodigious amounts of fuel, the "weight-losing" material par excellence. Other necessary ingredients may also have a ratio of weight-input to weight-output greater than one, but this fact is far overshadowed by the quantities of wood or coal required per pound of glass prod-

[20] Jarves, 2nd ed., p. 59.

[21] The demand for such types of glass was at that time relatively small.

uct. Glassmaking therefore may be considered a clear case of industrial localization dominated by fuel requirements, and from the days of ancient Egypt glass furnaces have always been found in areas abounding in supplies of heat and energy. It is this fact, too, which explains the glass industry's long history as a migrant art and the traditional mobility of workers in glass.

The American glass industry in 1820 was concentrated in Massachusetts, New Jersey, New York, Maryland, and Pennsylvania.[22] All but a few of the works representing these areas melted batch by wood fire and were therefore to be found in or near heavily wooded areas. Practically all of the New York works illustrate this determining force, as do also those in New Hampshire, the one at Chelmsford, Massachusetts, and later the one at Sandwich, Massachusetts. The same localization tendency seems to have existed in Connecticut, Maryland, and parts of Pennsylvania.

Within the limits of the localization range set by fuel supply two secondary factors acted upon choice of location. Whenever possible glasshouses were erected near workable deposits of the principal direct raw material, silica. The glassworks in New Jersey illustrate well the combined influence of these two forces; they were built in heavily wooded tracts of land but not far from the excellent Williamstown or Millville sand.[23] In New England many of the glasshouses attempted to use local sand before resorting to imports from New Jersey. Nearby sand resources seem also to have been used with considerable success in New York and parts of Pennsylvania.[24] Further, since almost all early domestic glassworks customarily imported certain glassmaking ingredients, availability of good facilities for water transport constituted another localizing factor. Water carriage provided the cheapest and most practical method of conveyance. Transportation was, of course, even more im-

[22] *Fourth Census.*

[23] Weeks, p. 97; "Glass-Making in New Jersey," *National Glass Budget,* XVI (April 6, 1901), 3.

[24] Weeks, pp. 77–98.

portant for the marketing of output. Provision for fuel supply then, together with considerations of transport and sand resource, combined to form the localization pattern of the American glass industry in 1820.[25]

It should be noted, however, that although most glass factories fired by wood and were located accordingly a few already used coal. Those at Pittsburgh had employed coal fuel for many years, deriving early advantage from an asset which later drew the glass industry to that region. Besides the Pittsburgh firms at least one eastern glassworks, the New England Glass Company, was burning coal. This concern and possibly one or two more in eastern coastal cities imported many raw materials; among these was coal which came by ship from Virginia.[26]

Processes and Techniques

In 1820 the methods, processes, and techniques of glassmaking in the United States were almost without exception indentical with contemporary European practice. In certain instances the methods of American glassmakers were hybrid forms of the individual peculiarities of the foreign art. In one way or another, however, the methods of manufacture — not only the technique of shaping and forming glass objects but also preliminary factors such as raw materials, fuels, furnaces, annealing ovens, and pot-making — were borrowed from the older glassmaking countries.

As has already been pointed out sand, the most important direct raw material of American glassmakers, was drawn from both local and distant domestic sources. From incidental in-

[25] However, not all glassworks were able to locate favorably from all three points of view. Since fuel was the consideration of first importance and sand of second importance some glassworks operated under a transport handicap. ("Development of the Glass Container Industry in the United States," *Glass Container,* II [August, 1923], 8)

[26] Watkins, p. 43. The glassworks importing coal appear to be exceptions to the localization rule. But it was not unknown at this time or later for a firm to remain in operation at a site originally determined by availability of wood fuel for some years after wood had been superseded by coal. True localizing factors always appear most clearly in the building of new industrial plants. This is particularly so in time periods which span technological change.

formation in the Census of 1820, it is evident that most of the glasshouses operating at that time obtained the alkali bases necessary to glassmaking in the form either of raw, pot, or pearl ashes; salt or a salt derivative; or from a combination of these.[27] Lime, kelp, and lead are also mentioned, the last by works producing flint glass.[28] Raw, pot, or pearl ashes were either processed from local wood supplies or imported from neighboring states; salt was usually imported; and lime and kelp was obtained domestically. The lead used by western glassmakers came from Missouri and Illinois; after 1818 eastern glasshouses drew supplies from a red-lead furnace operated by the New England Glass Company.[29] The solution of the fuel problem had already been indicated: most glassworks were located where wood of the proper type was easily available.[30] For the few eastern firms using coal, it was necessary to ship fuel from Virginia and Pennsylvania; the works at Pittsburgh were, of course, relieved of this burden.

Because many of the early glassmakers in the United States came from Germany, early glass furnaces strongly resembled those of the fatherland. In Germany wood was highly favored as a glassmaking fuel; its plentifulness in America encouraged the construction of furnaces similar to German ones. Not only were furnaces for window glass built in the German manner but early flint furnaces as well. The English workmen who introduced flint-making in the United States were accustomed to coal furnaces, but the initial scarcity of coal in most established glassmaking regions compelled them to adapt the German fur-

[27] As has been indicated above, the principal and essential constituents of glass are silica and an alkali or a metallic oxide. For green, common, cylinder, and crown glass the alkalies used were soda, lime, and potash. For flint, oxide of lead was substituted. (Weeks, pp. 19–21.)

[28] *Fourth Census.*

[29] Friends of Domestic Industry, New York Convention, October 26, 1831, *Address to the People of the United States* (1831), pp. 121–128, hereafter cited as *New York Tariff Convention; Documents Relative to the Manufactures in the United States* (1833), House Document No. 308, 22 Cong., 1 Sess.; hereafter cited as McLane, *Report on Manufactures.*

[30] Before being used in the furnace the wood was cut in four-foot lengths, about the thickness of one's wrist, and carefully dried in the ovens until it could be lighted from a candle (F. T. Irwin, *The Story of Sandwich Glass and Glass Workers* [1926], p. 29).

nace to flint production.[31] Window-glass furnaces were square or rectangular and the furnaces for flint or tableware were usually circular.[32] They were built either from sandstone cut to conform to the shape of the furnace or from fire brick.[33] The furnaces were usually small, one for window glass being recorded as only six feet by eight.[34] Jarves describes English flint furnaces eight feet in diameter at the interior base and six feet clear at the crown.[35] Construction provided a center fire grate on which the fire was built. Around this, near the inner walls, were set benches, arranged circularly in furnaces for flint and tableware and in two parallel lines in furnaces for window glass. Under the fire grate stood the ash pit, connected with the outside in such a way as to serve as an air channel to intensify combustion. In the side walls of the furnace were several openings for gathering the molten glass, and for reheating the "metal" (the molten glass), the blowpipes, and the iron rods.[36] In 1820, as later, clay pots for holding the molten glass were made entirely by hand. The clay, largely imported, was "treaded" or kneaded by the bare feet of workers.[37] After this long-continued operation the mixture was formed into long rolls out of which the pots were tediously built up by hand-shaping. The fashioning of a pot took about three months, the subsequent drying from two months to a year.[38] The earliest pots were very small — sometimes not much larger than a large water bucket, perhaps twenty inches in diameter — with a metal capacity of about 500 pounds. Those made at Sandwich

[31] Jarves, 2nd ed., pp. 100–101. For many years after 1820 bottles were made in the same furnace as window glass. When separate furnaces for bottles were built, however, they were practically identical with the former in design ("Modern Factory Construction," *National Glass Budget,* XIX [May 30, 1903], 1).

[32] Irwin, pp. 30–31.

[33] "High Grade Silica Brick, When First Invented," *Commoner and Glassworker,* XXIV (October 18, 1902), 19; "History of Plants," *Glassworker,* XXXVI (July 27, 1918), 20.

[34] "Small Pots and Hemlock Fuel Used in Window Glass Factory of 94 Years Ago," *American Glass Review,* LIII (January 13, 1934), 19.

[35] Jarves, 2nd ed., pp. 112–123.

[36] "Pittsburgh and the Glass Industry," *American Glass Review,* XLVI (March 26, 1927), 15.

[37] *New York Tariff Convention,* pp. 121–128.

[38] Irwin, pp. 34, 36; Watkins, p. 42.

and East Cambridge were larger, varying from 1500 to 2000 pounds in capacity.[39] Other units of glassmaking equipment included the annealing and flattening ovens and the glasshouse itself. The latter, like the furnaces, was at first half-English and half-German. The ovens were similar to the furnaces except of course on a very much smaller scale.

Glassmaking procedure preliminary to the actual forming or shaping was largely the same whether the product was to be window, bottle, common, or flint glass. After the batch had been prepared by a thorough mixing of the ingredients, it was subjected to a preliminary heating called "fritting,"[40] essential in these early days because of impurities in the alkalies. This done, the "frit" was placed in the clay pots, which meanwhile had been preheated in the tempering or annealing oven and set. Frequently more than one filling was necessary to complete the pot. The furnace was then driven to maximum heat and held at this point until the two phases of fusing and fining had been completed.[41] The inefficiency of the fuels and furnaces caused the process of melting to consume much time, sixteen hours being considered not unusual. Although it was customary for everyone to assist in the activities preceding melting, once this began most of the workers, who usually resided nearby, went to their homes to rest. The "teaser"[42] and his assistants, if any, supervised the long process of fining. When the glass was about ready for working, a watchman or perhaps a tending boy was sent to call the workers; it was a grievous offense for a worker to disregard the consequent hammering on his door, no matter what hour of day or night.[43]

In 1820 glass for glazing purposes was made by both the crown and cylinder processes, although the latter seems to have been more commonly employed.[44] The technique of making crown glass, the older of the two, may be described as follows.

[39] Weeks, p. 84; Watkins, p. 42.

[40] "Glass" in George Gregory, ed., *A Dictionary of the Arts and Sciences* (1822).

[41] Weeks, p. 43; Irwin, pp. 39–40.

[42] Weeks, p. 43. This term was apparently derived from the French *tiseur*.

[43] "Progress in Window Glass Manufacture," *National Glass Budget,* XXXIII (September 15, 1917), 1.

[44] *Fourth Census.*

When the materials were completely refined, the sandiver[45] removed, and the metal cooled to working temperature, the blower took his station by the gathering hole. By repeated dippings of the iron blowpipe into the crucible he gathered glass sufficient for the formation of a sheet of the usual size, about ten or eleven pounds. After rolling the mass of glass on a smooth iron table called the "marver" [46] to give it a cylinder form, he began to blow, causing the glass globe to become pear-shaped. By a second and third heating and by continued blowing the glass was increased in size and made more globular. The side opposite the blowpipe was then flattened by pressure against a smooth surface. A small portion of molten glass was gathered on the end of an iron rod called a "pontil" and applied to the center of the flattened side exactly opposite the blowpipe. The blowpipe was removed leaving a circular hole in the glass about two inches in diameter. At this point the glass was heated once more and the blower very deftly twirled the pontil in his hands in such a way that the hole made by detaching the blowpipe became larger and larger. As this rapid motion continued, the gradually flattening sphere suddenly flew completely open forming a plane surface fifty to sixty inches in diameter. The sheet when thus completed was detached from the pontil (leaving at that spot a lump known as a "bull's eye") and placed resting on its edge in the annealing oven.[47] After annealing, a time-consuming process, the plate was cut into small sheets, the center containing the bull's eye being retained for use in decorative glazing.[48] Crown, a glass of higher quality than cylinder, was sold in four grades, the fourth selling for about one-half the price of the first.[49]

Most glazing was done with glass variously known as cylinder, broad, or common window glass,[50] the preference arising from the larger sizes obtainable in this type and the lower costs

[45] A thick scum of unvolatilized salts, the result of impure materials (Weeks, p. 43).

[46] A corruption of the French *marbre,* marble being formerly employed.

[47] Porter in *Cabinet Cyclopaedia,* pp. 146–148; Gregory, *Dictionary;* Fowle, pp. 27–29.

[48] Fowle, p. 27.

[49] Porter, p. 148.

[50] Porter, p. 148.

involved.[51] The process of manufacture was similar to that of crown glass. After gathering metal on the blowpipe, in larger quantity than for crown glass, the workmen rolled the mass upon a block of wood hollowed to allow the lump to be extended to the diameter ultimately required for the cylinder. After the glass was worked into a pear shape, the blower blew and rolled it to the diameter desired. Then by a process of blowing and swinging, the cylinder was lengthened as much as possible. Finally the worker carried the glass to the fire, closed the mouthpiece of the blowpipe, and reheated the lower end of the cylinder. The heat caused the end of the cylinder to be forced open by the expansion of the interior air. The blowpipe was then removed from the other end of the cylinder. While still ductile, the cylinder was cut longitudinally with shears and flattened in an oven provided for the purpose. After being properly annealed the sheet was cut into desired sizes.[52]

When window glass was first manufactured in the United States, it was customary not only for the blower to gather his own glass but also to blow, cut, and flatten it.[53] In 1820 this was still common in many of the smaller factories.[54] Those operated on a larger scale frequently had assistants or apprentices who relieved the blowers of certain of the more minor and unskilled steps of the process. In time the division of labor was greatly elaborated; four separate trades eventually emerged from the process of making cylinder window glass. It should be noted that in Pittsburgh about this time it was usual to have one blower and one gatherer for each pot, both working until all of the metal in the pot had been consumed.[55]

Glass for purposes other than glazing — vessels and containers of all types — was made by two different processes known technically as "off-hand blowing" and "mold-blowing." Although both methods had been practiced by ancient glassmakers, off-hand blowing seems to have been the older of the

[51] Fowle, p. 31.

[52] Weeks, p. 50; Porter, p. 149; Fowle, pp. 32–38.

[53] "History of the Skilled Window Glass Workers' Trade," *Glassworker,* XXXV (August 11, 1917), 2.

[54] *American Glass Review,* January 13, 1934, p. 19.

[55] "Progress in Window Glass Manufacture," *National Glass Budget,* XXXIII (September 15, 1917), 1.

two. As in the formation of other objects of glass, the blower using the off-hand method made successive gathers until he had on the blowpipe an amount of metal appropriate to the article to be made. The gather was then expanded by blowing into a hollow globular form. If the shape of the intended vessel required the globe to be elongated, this was accomplished by swinging the pipe in an alternating motion similar to that of a pendulum or by dexterously and swiftly swinging it through the air. At this stage an assistant or apprentice, having gathered a small quantity of glass on a pontil, applied it to the globe on the side opposite the blowpipe and the glass was then detached from the blowpipe. After the glass was reheated the workman seated himself on a stool provided with forward-sloping arms on which the pontil was placed. With his left hand the blower proceeded to roll the rod backward and forward, while with his right hand he enlarged or contracted the vessel in different places until it assumed the desired form. The tool used in shaping the vessel was known as the "porcello," an iron instrument similar to sugar tongs, with blades connected by an elastic bow. Any superfluous material was cut away with scissors while the glass was red hot. To insure some regularity of shape and size, the workman was furnished with compasses and a scale marked off in feet and inches. When the article had been shaped, it was detached from the pontil and dropped into a box containing ashes, kept at the worker's side. It was then taken on a pronged stick or a wooden shovel to the annealing oven by the tending boy.

The process of blowing in a mold was closely similar to the off-hand method. In gathering the metal it was necessary to accumulate just the amount appropriate for the size of the mold. Instead of having its configuration determined by hand-shaping, the vessel was formed by blowing into the mass of glass while the mass was enclosed within the mold. After the article was removed from the mold, it was detached from the pipe and affixed as usual to a pontil for such hand-finishing as was necessary. In the case of bottles and allied ware finishing consisted of shearing the neck and, probably rarely, of fashioning the lip.[56] Although the use of molds in glassmaking was of great

[56] "The History of Glass Making. American Glassware for Drinking Purposes," *Glass Container*, VI (November 19, 1926), 9.

antiquity, only simple and rather crude varieties were employed in the United States of 1800. The two-piece hinged mold for bottles became common after that date, although by 1820 more complicated types, three- and even four-piece molds, were employed in certain of the larger factories.[57]

It appears that most, though not all, of the flint ware was blown off-hand.[58] It is probable that a large number of the articles made of non-flint metal were also formed in this way.[59] This was true of such very large containers as demijohns and carboys. Apparently some flint, perhaps a considerable portion of non-bottle green glassware, and most bottle glassware were mold-blown; Porter states that molds were customarily used "if it be required to give to the article any form or pattern which is unobtainable by the simple means narrated [off-hand blowing]."[60] The common use of molds for bottles and like containers arose from a desire to produce closely similar sizes and capacities.[61]

Competitive Position

Four factors weakened the competitive position of American glass manufacture before 1820: the want of the high degree of technical skill essential to the process of manufacture; the scarcity of skilled workers; the experimental nature of certain of the raw materials used; and the particularly effective status of the British exporters of glass.

Both the tradition and the essential nature of the art of glassmaking militated against the establishment of an early American glass industry based upon general public knowledge ~~of the~~ craft or upon a layman remembrance of methods practiced in the European countries. The traditional secrecy which had surrounded glassmaking from its earliest history had effectively

[57] "Glass Making," *Glass Container,* I (February, 1922), 18. See, for example, Watkins, pp. 45, 108–109.

[58] Watkins, *passim.* "An Interesting Glass Story," *National Glass Budget,* XXI (April 28, 1906), 1.

[59] Weeks, p. 96, citing the personal recollections of J. T. Bodine of Williamstown, New Jersey.

[60] Porter, pp. 140, 151.

[61] *Glass Container,* February, 1922, p. 18.

discouraged the creation of any usable fund of common public knowledge. More fundamental was the fact that the art of making objects from glass required a highly specialized skill obtainable only by rigorous training and long practice. There was, therefore, in the seventeenth, eighteenth, and nineteenth centuries a scarcity of skilled workers.

Because of the scarcity of skilled workmen, from earliest Colonial times the production of domestic glass and glassware was based upon importation of foreign workmen. Many examples of the frequency of this practice may be cited. Before the Revolution both Stiegel and Wistar had imported glassmakers, some to give instruction and others for employment in production.[62] The Stenger brothers who left Wistar and built a glasshouse in Gloucester County, New Jersey, were apprenticed foreign workers.[63] For his ambitious Maryland experiment John Frederick Amelung brought over a large number of glassmakers, mostly Germans. The first glass blowers employed by Albert Gallatin's New Geneva works were from this group. Foreign-born workers also dominated western glassmaking. The Craig and O'Hara glasshouse construction was supervised by Peter William Eichbaum, a German glassworker, formerly superintendent of a glassworks at the Falls of the Schuylkill near Philadelphia. William Price, an Englishman, made for the Craig and O'Hara company the first flint glass produced west of the Alleghenies. In the second glasshouse built in Pittsburgh a Frenchman named La Fleur was hired to take charge of the works.[64] Edward Ensell, closely identified with early flint production in Pittsburgh, was an English glassmaker who had been a manufacturer of both flint and window glass at Birmingham.[65] In New England the same condition existed; the Boston Glass Manufactory was compelled to postpone full operation from 1787 to 1792 because of "difficulties of procuring workmen and other embarrassments." [66] Jarves adds that the company was not really successful until the arrival of a German

[62] Bishop, I, 236–237; Weeks, pp. 80, 96.
[63] Weeks, p. 96; Walbridge, pp. 15–16.
[64] Weeks, pp. 82–83, 85, 95.
[65] Jarves, 2nd ed., p. 68.
[66] Weeks, p. 89.

superintendent by the name of Lindt. Again in 1811 the company brought in foreign glassworkers.[67] Robert Hewes in his attempt to make glass at Temple, New Hampshire, used Hessian and Waldecker army deserters who were competent glassmakers,[68] and as late as 1817 the New England Glass Company found it necessary to transport glass blowers from England and Scotland.[69]

The repeated importation of foreign glassworkers affords clear evidence of the scarcity of the specialized labor essential to glass manufacture. The degree of scarcity is emphasized by the fact that such action was undertaken at considerable expense and risk; Great Britain, for example, at this time prohibited the emigration of glass blowers and made it a penal offense to entice such workers away. Further evidence is found in the instances of sharp competition for the services of capable men. Jarves reports that the Boston Glass Manufactory suffered severely from labor-scouting. In 1810 or 1811 certain of their workmen broke indenture to accept increased wages offered by a glass factory projected at Utica, New York, but were arrested and brought back before arriving at their destination. Later, however, the company was less fortunate, losing a whole "set" of workers to an eventually unsuccessful experiment at Richmond, Virginia.[70]

In the earlier years not only were workers scarce but many of them were evidently without sufficient experience and hence were inefficient.[71] Dyott, referring to vial manufacture says, "Our knowledge of the business at this period [roughly 1812 to 1820–1825] was theoretical, without practice; and our workmen were equally deficient, having but an imperfect acquaintance with the mechanical part of their profession." [72] The experience of some of the earlier Pittsburgh works further

[67] Jarves, 2nd ed., pp. 56, 60.
[68] Weeks, p. 91.
[69] Watkins, p. 15.
[70] Jarves, 2nd ed., p. 59; Watkins, p. 163.
[71] These inefficient workers must have been primarily glassmakers who had received training in this country, although some of the immigrant blowers may have been drawn from the less desirable groups.
[72] Dyott, p. 15.

illustrate this point. Craig and O'Hara found in their first few years that the "men employed as superintendent and blowers did not always prove to be as highly skilled as their own assertions would have indicated." Bakewell and Page, flint manufacturers in Pittsburgh, went through similar difficulties.[73]

As a consequence of the scarcity of glassworkers, their bargaining power even in these early days was strong. They were able to command relatively high wages, and to some degree at least, to regulate output and apprenticeship. Jarves alleges that wages were three times as high as in Germany. He speaks also of "the great evil (which has too usually prevailed among the imported workmen) of a determination to prevent the instruction of apprentices by the most arbitrary and unjust means, and so far as was in their power, endeavoring to prevent competition, by not only controlling the hours of work, but the quantity of manufacture." [74]

The situation with respect to raw materials was a curious one. Although the United States at that time possessed almost all of the necessary glassmaking ingredients in great quantity and good quality, the best raw materials had not yet been discovered and hence could not be utilized.[75] This fact explains the continuous and expensive experimentation with raw materials which was generally characteristic of the period before 1820 and especially notable in the earlier years.[76] It also accounts for importation of raw materials.

A further difficulty confronting the American glass industry before 1820 was the presence of very effective competition from England. The British exporters operated through a series of agents located in the principal seaboard cities. These agents

[73] Weeks, pp. 84, 86.

[74] Jarves, 2nd ed., pp. 65, 69–70.

[75] For example in 1783 it was thought that the United States was totally lacking in two highly important elements of glass manufacture, clay for pots and flint. Flint had not been discovered because of cheap and easily available imported gunflints. Appreciable quantities of flint were also imported in chalk brought as ballast from England. During the War of 1812 the British, believing flint was not obtainable here, ordered vessels to carry no chalk as ballast, fearing the "flint stones" contained therein might be used to their own detriment. (Bishop, I, 239.)

[76] Munsell, III, 167.

apparently were efficient merchandisers; they customarily made careful surveys of the needs of local dealers, traveling, selling by sample, and then ordering from their principals accordingly. Not only did they import for other dealers but they also made retail sales at low prices, guaranteeing to sell as much as was wanted of every article at less than the cost of domestic manufacture. In the years following the War of 1812 price competition was severe; one Boston agent advertised that he would sell his ware at 25 per cent less than the prices asked at local factories for similar or inferior ware.[77] In quoting low prices the English exporters and their agents were substantially aided by the bounty then granted on exports of English glass.[78] The

[77] *Niles' Weekly Register,* XVI, 403.

[78] Jarves, 2nd ed., pp. 81–83. Jarves's historical sketch of the English bounty is worth quoting entirely: "To stimulate the exportation of various articles of English production the government, in the latter part of the eighteenth century, granted bounties, from time to time, on linens, printed cottons, glass, etc., etc. Until the bounty on glass was allowed, the exportation of glass from England to foreign countries was very limited; for the French and German, as has before been stated, for various reasons could undersell the English; but the government bounty changed the aspect of affairs, and shortly the English manufacturers not only competed with the Germans and French for the foreign market, but actually excluded them from any participation,—the government bounty being equal to one half the actual cost of the glass exported.

"An Act of Parliament levied on flint-glass an excise duty of ninety-eight shillings sterling on all glass made in England, which excise was paid by the manufacturer, being about twenty-five cents per pound weight, without regard to quality; but if such glass was exported, the excise officer repaid the tax which it was presumed the manufacturers had paid, and a clear bounty of twenty-one shillings sterling was paid by the government to the exporter on each hundred weight of flint-glass shipped from England, being equal to five cents per pound. Under such encouragement the export increased from year to year to a very great extent, so that the excise duty of ninety-eight shillings sterling on the amount consumed at home did not equal the amount paid out in bounty. In the year 1812, fifty-second George III, an Act was passed reducing the excise duty to forty-nine shillings, and the export bounty to ten shillings sixpence. In 1815 the Act was renewed, and again in 1816. In 1825, sixth George IV, chap. 117, an Act was passed revising the former as to the mode of levying the excise duty and bounty, so as to prevent frauds on the revenue, which had hitherto been practised to a very great extent. This act remained in force until the Premiership of Sir Robert Peel, when both excise and bounty were abrogated, and the English manufacture stands on the same footing in foreign countries as those of other nations. By the protecting hand of the English Government the flint-glass manufactories multiplied with very great rapidity, underselling all other nations, and not only rivalling, but far excelling them in the beauty, brilliancy, and density of the articles manufactured."

English trade was also aided by the fact that foreign products were almost invariably preferred by American purchasers, for the quality of American glassware was generally inferior to the imported.[79]

To offset partially its disadvantages, American glass manufacture possessed certain advantages or compensations. The first was the presence of a cheap and easily available fuel supply. This was a factor of distinct importance because next to labor fuel was the item of greatest cost in production. Since most of the glassworks burned wood, the industry as a whole enjoyed an advantage. A second advantage lay in the fact that the domestic industry was developing within a market which was expanding with great rapidity and which placed less stress upon fine quality, perfection, and high beauty than upon serviceability and convenience. In this type of market, or this portion of it, American glassware could compete with some degree of success. For practical purposes it made small difference that domestically produced window panes were somewhat off color and not as clear or flat as one might wish. Nor was it at that time a matter of great moment that decanters and other tableware were rudely colored and not clearly transparent; nor that bottles frequently stood askew and were crudely formed about the neck and lip. In spite of such shortcomings, domestic products served practical ends sufficiently well. A third advantage, or rather compensation, arose from the augmentation of import prices because of carrying and breakage costs. These costs were of greater significance in the case of containers and hollow ware than in the case of window glass, which required less space and was more readily packed. A fourth source of compensation for the difficulties of American glassmaking was found in the tariffs laid upon importations of foreign glass and glassware.

Tariff Policy

From the beginning of the tariff history of the United States the glass industry was considered a branch of domestic manufacture needing and deserving national encouragement. In 1789 during a debate in Congress on the wisdom of levying duties for

[79] Dyott, p. 15.

the protection of various industries Daniel Carroll of Maryland proposed a 10 per cent duty on window and other glass except black quart bottles. He gave as a reason for his resolution the recent and promising establishment of glassworks in Maryland.[80] Before this event certain craftsmen of Baltimore, the glassmakers included, had requested in a petition to Congress that provision be made for their encouragement. Furthermore, the ambitious project of John Frederick Amelung near Frederick, Maryland, is known to have been in difficulty at this time.[81] Debate on the Carroll resolution was brief; it is reported merely that there took place a "desultory" conversation on the propriety of introducing the matter at that time.[82] In the bill finally enacted the rate on glass stood as originally proposed.[83]

In the eleven years following the formulation of the first tariff the duties on glass and other commodities were increased commensurately with the need for revenue. In 1790 the rate on "looking glasses, window and other glass, and all manufactures of glass (black quart bottles excepted)" was increased by 2½ per cent. Black bottles continued at 5 per cent. Two years later the general duty on glass was raised by another 2½ per cent and the rate on black bottles was also raised in consequence of the new 2½ per cent levied upon non-enumerated articles. In 1794 a further duty of 5 per cent was imposed on all glass (except window and the preferred bottles), bringing the general rate for glass to 20 per cent. Window glass remained at the previously prevailing level of 15 per cent. Black bottles carried 10 per cent after the addition of a second 2½ per cent specified for non-enumerated commodities in this bill. The supplementary enactment of 1795 required that bottles imported with liquor contents should be taxed as if empty. The only effect of the act

[80] [*Annals of Congress*] *Debates and Proceedings in the Congress of the United States* (1834), I, 167; hereafter cited as *Debates and Proceedings in Congress.* Domestic production of black quart bottles was insufficient to supply the containers necessary for the large trade in beverages of various kinds. Since they were specifically exempted from the 10 per cent duty the bottles came in under the "not otherwise provided for" rate of 5 per cent.

[81] *American State Papers: Finance* (1832), I, 5, 62.

[82] *Debates and Proceedings in Congress,* I, 167.

[83] House of Representatives, *Tariff Acts, 1789 to 1909,* Document No. 671, 61 Cong., 2 Sess. (1909), p. 13; hereafter cited as *Tariff Acts.*

of May 13, 1800, levying additional duties on certain articles, was once more to augment by 2½ per cent the rate on all non-enumerated commodities, black bottles among them.[84] Between 1802 and 1804 there is evidence of pressure on Congress for higher duties on glass imports. In 1802 the makers of glass bottles and glassware of all kinds asked Congress for greater assistance. The report of the committee considering the petition was mildly favorable, recommending an all-inclusive rate of 20 per cent. In 1803 further petitions were made and reported by the Committee of Commerce and Manufactures. The following year renewed pressure induced the same committee to recommend a duty of 25 per cent on window glass and black quart bottles in place of the formerly prevailing rates of 15 and 12½ per cents.[85]

The persistent efforts of the glassmakers to increase their tariff protection bore fruit in 1804 even though the first tariff act of that year was purely a revenue measure. It provided a blanket increase of 2½ per cent on all ad valorem rates. The act of March 27, however, made provision for the first specific duties on glass: the frequently mentioned black quart bottles were now dutiable at 60 cents a gross; window glass (not above 8 x 10 inches) at $1.60 per hundred square feet and the larger sizes (not above and above 10 x 12 inches) at $1.75 and $2.25.[86]

No further alteration in the tariff on glass was made until 1812 when because of the war all permanent duties were doubled; this provision was continued in the act of February, 1816, to June of that year. Meantime, in April, 1816, the first general revision of the tariff was completed. Little change was made in the general level of the glass tariff, a rate of 20 per cent being maintained. The specific duty on black bottles, however, was more than doubled, reaching now $1.44 per gross. The duties on window glass were increased by an average of 52 per cent, the rates for the three sizes being $2.50, $2.75, and $3.25. Until the tariff of 1824 no later modifications were made except for a 30 per cent enactment for cut glass in 1818.[87]

[84] *Tariff Acts,* pp. 15, 34, 40, 42, 46.
[85] *American State Papers: Finance* (1832), I, 730; II, 29, 80.
[86] *Tariff Acts,* pp. 48, 49.
[87] *Tariff Acts,* pp. 54, 56, 57, 68.

The tariff on glass before 1824 may be summarized as follows. The general duty on glass and glassware, beginning at 10 per cent in 1789, moved up rapidly to 20 per cent in 1794 and remained at this figure until 1804; from 1804 to 1816 it was 22½ per cent (except for the war period during which all permanent duties were doubled); from 1816 to 1824 the rate was maintained at 20 per cent. The duty on window glass was identical with that of the general classification until 1794, when the former was held at 15 per cent and the latter increased. In 1804 the average specific duty was about $1.85 per box. It is difficult to compute an ad valorem equivalent that will be even roughly accurate. If, however, the average import price of window glass was equal to the domestic western selling price current about this time,[88] then the equivalent duty would be near 23 per cent. The fact that the Committee on Commerce and Manufactures in 1804 had recommended a 25 per cent levy for window glass lends some validity to this estimate since it is not unreasonable to suppose that the selection of specific rates was guided by its recommendation. The increases of 1816 are equally difficult to reduce to equivalents, but estimating on the same basis as before the average rate would be about 35 per cent.[89] The 1816 duties were unchanged in 1820.

The duty on black quart bottles began at 5 per cent, was increased to 7½ per cent in 1792, to 10 per cent in 1794, and to 12½ per cent in 1800. Although no price data have been found

[88] It is probable that the average import price was below the comparable western quotation by at least the amount of transportation cost. If so the equivalent rate was considerably above 23 per cent. But there may have been a counteracting factor from the superior quality and higher price of the imported glass.

To estimate the 1804 domestic western prices I have used the data supplied by one of the Pennsylvania glass factories reporting to McLane. The firm says that ten or fifteen years after its founding (a few years before 1800) the price of window glass (no size or quality specified) had declined to $8.00 a box (McLane, *Report on Manufactures,* II, 531–532).

[89] The Pennsylvania firm, whose price quotations in the McLane report were used in the 1804 estimate, says that during the war period window glass was fractionally higher than $8.00. The figure used is $8.00 rather than anything above because of the offset in the lower price tendency induced by enlarged imports. These may have had some effect by the time the tariff of 1816 was drawn. See McLane, *Report on Manufactures,* II, 521, 531.

disadvantages of the American industry prompted petitions for higher duties from which followed the specific rates of 1804. The increases then provided, even though beneficial, were still insufficient to equate domestic costs and import prices; imports, therefore, continued to be very heavy (see Table 1).

TABLE 1

IMPORTS OF WINDOW GLASS, 1805–1820

Year	Square feet	Year	Square feet
1805	917,700	1813	628,700
1806	3,012,900	1814	279,300
1807	3,077,400	1815	269,700
1808	2,465,400	1816	2,241,200
1809	427,900	1817	1,440,700
1810	2,653,200	1818	1,431,900
1811	2,902,400	1819	1,241,100
1812	752,400	1820	627,100

Data from Secretary of the Treasury, *Reports, 1790–1828* (1828–29) Figures for 1816 and 1817 from *Niles' Weekly Register*, XV, XVI

In 1808 and 1809 the consequences of restrictive legislation are apparent. Imports declined sharply (see Table 1) and the domestic industry began to expand more rapidly. By the time of the Census of 1810 domestic production had reached 65 per cent of the total consumed.[92] From 1812 to 1815 glasshouses producing window glass enjoyed heavier protection; all permanent duties had been doubled by the act of July 1, 1812, and imports were further hampered by the circumstances of war. Great expansion of domestic manufacture followed. Imports were negligible (see Table 1) and domestic production increased to approximate total consumption.[93]

During and after the war further experimentation, enlarged

[92] *American State Papers: Finance* (1832), II, 685. Window glass is here classified as an industry firmly established, supplying the greater or a considerable part of total consumption.

[93] *American State Papers: Finance* (1834), III, 85. In 1816 window glass is classified as an industry firmly and permanently established which wholly or almost wholly satisfied domestic demand.

experience, and a supply of labor increased by apprenticeship and renewed immigration from abroad continued to improve the competitive position of domestic glasshouses. The most pressing problems were solved with difficulty, but they were solved. More important, the tariff of 1816 raised the tariff which existed before the war by over 50 per cent. The effect of a stronger tariff and of lower domestic costs and prices is reflected in the quantities imported between 1817 and 1820 (see Table 1).[94] Despite the English export bounty and despite depression domestic window-glass manufacturers in 1820 were in a position to dominate the market in the United States.

It is difficult to appraise accurately the effect of the tariff on domestic production of common glassware. With one exception no usable statistics of quantities imported have been found; further inconvenience arises from the variety of products and the rarity of price quotations for them. It is probable that bottles, vials, and related objects were quantitatively most important. From earliest times rude objects of this class had been manufactured domestically, American glassworks deriving advantage from the higher transportation and breakage costs involved in the importation of this type of glass.[95] The common practice of using certain of the pots in window-glass furnaces for bottles and green glassware makes it impossible even as late as 1820 to cite the number of works producing such products. Probably all of the glasshouses in existence at various points of time manufactured at least a small quantity.

By 1800 a 20 per cent tariff had not prevented satisfaction of the major portion of demand by importations. At the time of the first census of manufactures the value of glass produced for purposes other than glazing amounted to only about $240,000; of this total the larger portion was attributable to common glassware. In the same year, 1810, this branch of glassmaking was said to supply only a small portion of the total

[94] Western prices after 1797 for window glass per box of 100 square feet, no size or quality specified, are quoted as follows: 1797, $12.00; 1807–1812, $8.00; 1812–1815, $8.00+; 1822–1825, $5.00 (McLane, *Report on Manufactures,* II, 531–532).

[95] Window glass was more effectively packed and consumed less space in shipment.

consumed.[96] During the expansion period efforts were made to enlarge domestic production but without conspicuous or permanent success; even in 1816 common glassmaking was classified as an industry so slightly cultivated as to leave the demand of the country almost wholly in the hands of foreign sources.[97] Only the manufacture of vials was excepted from this judgment.[98] Ten years of 20 per cent, eight years of 22½ per cent, and four years of 42½ per cent tariff protection apparently proved insufficient counterbalance for the difficulties and higher costs of domestic manufacture.

One phase of common glassmaking requires further comment. From 1789 the supply of black quart bottles had been a matter of especial importance because of the heavy demand for suitable beverage containers. Alexander Hamilton in 1791 mentioned the complaints arising from their scarcity, and the deficiency was reflected in the act of 1789 which permitted importation at 5 instead of 10 per cent. The specific duty of 1804 was the first real attempt to expand domestic production ade-

TABLE 2

IMPORTS OF BLACK QUART BOTTLES, 1805–1820

Year	Gross	Year	Gross
1805	8,286	1813	3,395
1806	15,174	1814	1,877
1807	20,273	1815	850
1808	15,444	1816	37,325
1809	2,613	1817	16,948
1810	6,584	1818	19,350
1811	20,104	1819	13,184
1812	3,071	1820	9,379

Data from Secretary of the Treasury, *Reports, 1790–1828*. Figures for 1816, 1817 from *Niles' Weekly Register*, XV, XVI.

[96] *American State Papers: Finance* (1832), II, 685.

[97] Dyott, p. 15; *American State Papers: Finance* (1834), III, 85.

[98] Dyott, himself engaged in the production of this branch of common glassware, cites the increased output of vials during the war period. From 1815 to 1822 an increased domestic supply and the competition of foreign imports caused prices of all types and sizes to fall appreciably. (Dyott, pp. 15, 53.)

quately, but that this was unsuccessful is indicated by the rapid growth of imports from 1805 to 1808 (see Table 2). As with window glass restrictive legislation caused sharp declines in imports, yet in 1811 imports were very heavy, and after the War of 1812 black bottles were imported in unprecedented quantities. In the tariff of 1816 the former specific duty was more than doubled.[99] That this operated as a partial deterrent may be seen from the lower import figures for 1817–1820. The continued magnitude of the figures, however, is indicative of the notably inferior competitive position of this branch of domestic glassmaking.

Early American glassmakers quite wisely directed their major effort to the production of objects serving the more primary and immediate needs of consumers. It was this class of commodities that was in greatest demand; in the making of these products the manufacturers were also at least disadvantage. Production of fine flint glassware before 1800 was negligible. Successive tariffs of 10, 12½, 15, and 20 per cent were all entirely inadequate to protect the domestic producer from the more effectively organized, more skillfully manned foreign glassworks. Between 1800 and 1810 only a small quantity of flint glass was made in the United States. The handicaps of American glassmaking bore heavily upon any attempt to produce a type of glass requiring a high degree of technical knowledge, purity of materials, and much skilled workmanship. Flint glassmaking was, therefore, significantly unsuccessful.[100] The protection of the war period permitted some expansion of domestically manufactured products, particularly at Pittsburgh, but with the termination of this temporary stimulus, and with the renewal of a 20 per cent tariff, the value of output shrank rapidly.[101] Like common glassware and black bottles, flint production in 1816 was admittedly only slightly cultivated; by 1820, the census reports indicate that it was produced by but five firms.[102]

[99] $1.44 per gross instead of 60 cents.

[100] *American State Papers: Finance* (1832), II, 685.

[101] Weeks, p. 87. Between 1815 and 1819 the value of flint glass produced at Pittsburgh declined by $75,000.

[102] *American State Papers: Finance* (1834), III, 85. Value of output was less than $127,000 (*Fourth Census*).

Of these the New England Glass Company was the most important and most successful, its position being attributable in large part to superior technical management and to the importation of very fine workmen.[103] The disadvantages confronting this branch of the American glass industry were not to be overcome by the imposition of a moderate tariff. Indeed technical and labor conditions were such as to make success improbable even had extreme tariff protection been attempted. Permanent and successful flint manufacture in the United States could come only with substantial improvement in the state of the art.

[103] Watkins, *passim.*

CHAPTER V

THE DEVELOPMENT OF THE GLASS INDUSTRY TO THE CIVIL WAR

FOR SEVERAL YEARS after the depressed conditions of 1820 the American glass industry underwent no important change. General economic revival gradually removed the circumstances complained of in the Census of 1820, but there is little evidence of additions to plant or equipment. The productive capacity of 1820 was sufficient to supply the augmented demand of more prosperous times.[1] A contemporary report by the Secretary of the Treasury on the state of manufactures affords clear evidence of the absence of any expansion before 1824. The value of glass products is not separably reported but the total number of firms listed in the tables is less than the number indicated for 1820.[2]

EXPANSION OF OUTPUT

Between 1825 and 1831 American glassmaking appears to have experienced an era of expansion even more rapid and extensive than that which followed the declaration of war in 1812. By the third decade of the nineteenth century, however, the building of new glasshouses had ceased to be an event worthy of particular attention and the account of glasshouse construction in the years preceding 1831 is less complete than in earlier years. The records are nevertheless sufficient to indicate the magnitude of the growth. In 1826 western Pennsylvania was said to possess eight window-glass works and not more than two

[1] Weeks, pp. 77–98. It is probable that not more than one or two new glasshouses were built between 1820 and 1824. I have found reference to only one known definitely to have begun operations within this period; this was built in New Jersey and first manufactured glass in 1822.

[2] The number of glassworks reported in the Census of 1820 was thirty-four while the 1824 figure is twenty-eight (*Senate Documents, 1823–24,* No. 45, 18 Cong., 1 Sess.).

flint-glass houses.[3] In 1831 eighteen or nineteen glass factories are reported for the same area, an increase of eight or nine firms in a period of six years.[4] Moreover, in the interval between 1827 and 1832 four new enterprises were founded in New Jersey and the same number in western Virginia.[5] Thus from 1826 to 1831 at least sixteen or seventeen new glassworks came into existence, a total nearly equivalent to 50 per cent of the number reported in the Census of 1820.

No official statistical survey of the glass industry was made in 1830; the third census of manufactures, which should have been taken at this time, was postponed ten years. It is therefore necessary to turn to other sources for evidence of the increased production which accompanied this new wave of glasshouse construction. A substitute is available in the committee reports of the New York Tariff Convention of 1831. The brief but highly valuable comments of the Committee on the Manufacture of Glass provide sufficient information for an appraisal of the growth which had occurred by 1831. The utility of this report is modified but not vitiated by the high degree of estimate in the data presented and the obvious influence of protectionist bias.[6]

The best summary evidence of the expansion of the American glass industry is found in the total value of glass reported produced in 1831. The Committee's estimate, apparently made with care, is $2,501,000.[7] This represents a more than 200 per cent

[3] The number of flint works is not given but since the value of flint output was only $30,000 it is clear that not more than two firms, and probably only one, were responsible for this product.

[4] Weeks, p. 87. The exact number is not reported.

[5] Weeks, pp. 78–79, 96.

[6] Friends of Domestic Industry, New York Convention, 1831, *Address to the People of the United States* (cited as *New York Tariff Convention*).

Most of the totals derived are dependent upon estimates, but the methods of estimate are usually stated and on the whole seem to have been carried out with care and an honest attempt at precision. If any general error exists it no doubt lies in an exaggeration of the magnitude of all lines of domestic production.

[7] *New York Tariff Convention,* p. 126. The appendix to the committee's report increases the estimate to $3,000,000 but I have employed the lower figure since the appendix does not clearly indicate that the additional data there submitted were not already included in the estimates made by the reporting committee.

increase over the $788,000 estimated for 1820. Nor is any appreciable portion of this value increase attributable to price rise. Indeed the trend of glass prices up to 1831 was not rising but falling. Equally striking is the increased importance of domestic production in total consumption. Domestic production constituted 69 per cent of consumption in 1820; eleven years later the figure had become 83 per cent.[8] All branches of glass production shared in the expansion. The total value of window glass domestically manufactured slightly exceeded $1,000,000. Compared with the $547,980 estimated for 1820 this was an increase of 83 per cent. Of the $1,000,000 total, $851,000 was attributed to cylinder window glass, reflecting the continuing and probably increasing domination of cylinder production over crown production.[9] Also significant was the altered importance of window glass in total production. Although this branch of the industry represented 70 per cent of all glass manufactured in 1820 it accounted for but 40 per cent in 1831. Domestic production of window glass in 1820 constituted 89 per cent of total consumption of this glass type and 94 per cent in 1831.

Explanation of the radical change in the relative importance of window glass in total production is found in the great expansion between 1820 and 1831 of flint and common glassware, particularly the former. The total of their combined production constituted about $240,000 in 1820 but $1,500,000 in 1831, an augmentation of more than 500 per cent.[10] In consequence, flint and common glassware produced in the United States was at least 77 per cent of the total consumption of such goods in 1831, though only slightly more than 50 per cent in 1820.[11]

The most remarkable feature of the expansion of the glass industry between 1820 and 1831 manifests itself, however, in the rapid strides of flint-glass production. The Census of 1820 listed but five factories to which flint-glass production could be imputed. In 1831 the New York Tariff Convention Committee on Glass listed and specifically designated as devoted to the

[8] Total production in 1820 was $788,000 and imports in 1821 totaled $350,000.

[9] *New York Tariff Convention,* p. 126.

[10] *New York Tariff Convention,* p. 126.

[11] For flint- and common-glass production and import figures in 1820 see Chapter IV. In 1831 production totaled $1,500,000 and imports $440,000.

production of fine glassware twenty-one furnaces with a capacity of 140 pots.[12] These data, which contain no element of estimate, afford eloquent testimony of growth. The twenty-one furnaces were contained in seventeen glasshouses.[13] The three most important producing centers were Boston and vicinity (six furnaces and thirty-eight pots), Pittsburgh (four furnaces and thirty-two pots), and New York and its environs (three furnaces and twenty-two pots). The remaining eight furnaces were located at Philadelphia, Providence, Baltimore, and Wellsburg and Wheeling in western Virginia.[14] Total value of output was estimated at $1,300,000, more than ten times the probable production of 1820 and slightly over 90 per cent of total consumption.[15]

The growth of common glassware production from 1820 to 1831 can be described less precisely. The report of 1831 records the existence of one firm engaged in the manufacture of black bottles and "several" producing green bottles, demijohns, carboys, apothecaries' ware and "shop furniture." The largest of the latter was said to be the works of Dr. Dyott near Philadelphia. The total output of glass bottles, "phials," apothecaries' ware, demijohns and carboys was estimated by the Committee on Glass at $200,000 and imports of similar ware at $75,000.[16] These figures indicate not only augmented production but also a strong position of domestic output in total consumption (73 per cent). In 1820 total output of common glassware was approximately $113,300. Since the $200,000 estimated by the committee apparently omits domestic production of certain classes of common glassware included in the 1820 total, it seems just to conclude that production of common glassware in 1831 was more than 75 per cent greater than in 1820.[17]

[12] *New York Tariff Convention,* p. 121.

[13] *Niles' Weekly Register,* LXX, 127. The tariff convention report does not give the number of glasshouses but Niles reports seventeen in existence in 1832.

[14] *New York Tariff Convention,* p. 121.

[15] Flint imports were estimated by the Committee on Glass at $125,000. *Commerce and Navigation* tables do not report flint imports separately.

[16] *New York Tariff Convention,* pp. 123, 124.

[17] For the range of products probably included in the total for 1820 see Chapter IV.

The course of growth and development of the American glass industry from 1831 to 1860 is reflected in the third, fourth, and fifth censuses of manufactures. The third, taken in 1840, reports the total value of glass products made in the United States as $2,890,293.[18] Although this represents a relatively small increase over the estimated total of 1831, the appearance of a reduced rate of growth cannot be considered surprising, for by 1831 the most fertile field for the rapid expansion of domestic production, displacement of imports, had been well cultivated. Thereafter expansion became dependent upon the less spectacular factors of growth of population and extension of demand.[19]

From 1831 to 1850 the percentage of total consumption of glass and glassware supplied by domestic production varied as follows: 83 per cent in 1831, 84 per cent in 1840, and 81 per cent in 1850.[20] Between 1840 and 1850, however, value of output greatly increased. The fourth census of manufactures reported a total of $4,641,676, an advance of 66 per cent over a ten year period. This rate of growth is substantiated by the change in the number of persons employed, an increase of 72 per cent.[21] Despite such notable augmentation of domestic production, the industry's contribution to total consumption declined.

[18] U.S. Department of State, *Enumeration of the Inhabitants and Statistics of the United States from the Returns of the Sixth Census* (1841); hereafter cited as *Sixth Census*.

[19] It must not be forgotten, however, that in so far as the estimates of 1831 were exaggerated, the true rate of growth between 1831 and 1840 is understated. The fact that the number of persons employed in the industry in 1840 was fully 50 per cent greater than the estimate given by the Committee on Glass, though the value of products was only 16 per cent greater, appears to throw some suspicion upon the 1831 estimates. But this is nowise conclusive for the committee may well have been in error, or in greater error, in its appraisal of employment, an estimate of less interest and apparently made with less precision than the estimate for the value of output. Although this conflict of evidence could be neatly reconciled by sharply falling glass prices, there exists no basis for such a solution.

[20]

	1831	1840	1850
Total production	$2,501,000	$2,890,293	$4,641,676
Total imports	510,000	560,000	1,070,000

[21] Department of the Interior, *Abstract of the Statistics of Manufactures according to the Returns of the Seventh Census* (1859); hereafter cited as *Seventh Census*.

In 1860 the total value of glass products attributable to American manufacture, $8,512,305, was 83 per cent greater than in 1850.[22] As in the preceding decade, however, rapid and extensive growth failed to alter substantially the portion of total consumption provided by domestic production. The proportion in 1860 was very slightly below the 1850 level, 80 instead of 81 per cent.[23]

In sharp contrast to the rate of increase of domestic production of glazing glass before 1820 and between 1820 and 1831, in the thirty year period preceding 1860 the total value of window glass manufactured in the United States advanced by only 42 per cent.[24] The total value of output at the time of the eighth census was but $418,520 above the $1,000,000 estimated for 1831, and during this same period window-glass prices appear to have fallen but slightly.[25] Domestic window-glass production, which in 1831 was 40 per cent of total glass production and 94

[22] Department of the Interior, Census Office, *Manufactures of the United States in 1860, Compiled from the Eighth Census* (1865); hereafter cited as *Eighth Census.*

[23] 1860: Total production, $8,512,305; total imports, $2,170,000.

[24] *Eighth Census.* Unlike the Census of 1840 and of 1850, the 1860 census of manufactures reports not merely summary data descriptive of the industry as a whole, but, happily, the number of firms and values of output of the separate branches of glass manufacture. Since county and state glass statistics are consistently designated as pertaining to either glassware, window glass, or plate, never to any less precise or more ambiguous division of the industry, it seems just to accept these classifications as mutually exclusive; i.e., that the totals for glassware, for example, include no portion of output properly attributable to window-glass or plate production, and vice versa. Were this not so, the conclusions drawn from the data on glass in the Census of 1860 would be completely vitiated.

[25] The following quotation strongly supports the accuracy of the window-glass production total reported in the Census of 1860. "The average number of square feet of glass for a dwelling may be placed at 100. The number of houses in the United States in 1850 was 3,363,427 which would require, in round numbers, 336,000,000 feet. In 1860 the number of dwellings was about 4,700,000 requiring 470.000,000 feet of glass, or an increase of 134,000,000 feet for new dwellings alone, without taking into account breakage, rebuilding, churches, hot-houses, public buildings, etc. The value of the new glass required would be about $4,500,000." (*Eighty Years' Progress of the United States, 1781-1861* [1864], p. 403; hereafter cited as *Eighty Years' Progress of the United States.*) This amount of glass could easily have been supplied by the yearly production stated for 1860. Moreover, exports of window glass were insignificant and imports important.

per cent of total window-glass consumption, in 1860 constituted but 16 per cent of total glass production and, more important, only 65 per cent of total consumption of window glass.[26]

Combined production totals for flint and common glassware manifest contrary development. Total value of output in 1831 was $1,500,000 and in 1860 was $7,063,785, a 370 per cent increase in thirty years.[27] In 1831 the products of the two branches together constituted 60 per cent of total glass production and 77 per cent of flint and common glassware consumption; in 1860 their share in total production had become 83 per cent and in total consumption of this class of glassware 88 per cent.[28]

Localization

The forty years which preceded the Civil War wrought no fundamental change in the location of American glass factories. The four major glass-producing regions of 1820 remained dominant in 1840 and 1860. In this period no new factors entered the determination of sites chosen for new glasshouses. Moreover, since there was no improvement of glassmaking practice comparable to the later introduction of the tank furnace, the advantage of production in the coal-producing areas did not for the greater part of the period prove irresistible, at least not for the majority of glasshouses already established. Three trends characterized the reorientation that occurred: the declining significance of New York and New Jersey; the slow but consistent rise of the region west of the Alleghenies; and the continued though diminishing importance of New England. (See Table 3 and Table 4).

Although New York and New England in 1860 still held preeminent rank as producers of fine glassware, their quantitative importance as glassmaking regions had by this time declined.[29]

[26]

	1831	1860
Window-glass production	$1,000,000	$1,418,520
Window-glass imports	60,000	750,000

[27] *Eighth Census.*

[28]

	1831	1860
Flint and common glassware production	$1,500,000	$7,063,785
Flint and common glassware imports	440,000	980,000

[29] "Historical Data About Glass," *National Glass Budget,* XVII (August 10, 1901), 1.

Of the thirty-three glasshouses active in 1820 the New England states possessed eight — four in Massachusetts, two in Connecticut, and two in New Hampshire. Twenty years later, although the total number of active glasshouses had increased by forty-eight, there were only three additional glasshouses in this area. By 1860 Massachusetts had eleven (an increase of seven) but both Connecticut and New Hampshire still had but two.

TABLE 3

LOCATION OF AMERICAN GLASS FACTORIES, 1820, 1840, 1860

	New England		The West[a]		New Jersey		New York		Maryland and Eastern Pa.		Total number
	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	
1820	8	24	9	27	5	15	7	21	4	12	33[b]
1840	11	14	31	38	23	28	13	16	3	4	81
1860	15	17	30	34	16	18	18	20	9	10	89[c]

Data from *Fourth Census*, *Sixth Census*, *Eighth Census*.
[a] The West refers to the region west of the Alleghenies
[b] One of the 34 factories mentioned in the Census of 1820 is reported out of operation and is therefore not included in the table
[c] One factory located in Jefferson County, Kentucky, is included in the total figure.

Statistics of the value of glass produced in New England from 1820 to 1860 continuously indicate greater importance than suggested by the number of factories. Glass made in Massachusetts, Connecticut, and New Hampshire constituted 36 per cent of total output in 1820 and placed New England first in glassmaking significance. By 1840, however, the percentage had declined to 21, and even the great augmentation of output which had occurred by 1860 raised New England's proportion of the total output to only 25 per cent. In value of output New England ranked first in 1820, third in 1840, and second in 1860.

The number of glassworks in New York increased in both 1840 and 1860. This development, however, was offset by a declining trend not only in the proportion of total glass factories but also in percentage of total output. Both decreases reflect

TABLE 4

REGIONAL DISTRIBUTION OF AMERICAN GLASS PRODUCTION, 1820, 1840, 1860

	New England		The West[a]		New Jersey		New York		Maryland and Eastern Pa.		Total value
	Value $	% of total	Value $	% of total	Value $	% of total	Value $	% of total	Value $	% of total	
1820[b]	285,250	36	181,680	23	69,000	9	151,900	19	100,000	13	787,830
1840[c]	605,000	21	856,222	30	904,700	31	411,371	14	110,000	4	2,890,293
1860[d]	2,094,576	25	2,909,543	34	1,098,000	14	1,198,186	14	1,147,000	13	8,512,305

Data from *Fourth Census*, *Sixth Census*, *Eighth Census*.

[a] The West refers to the region west of the Alleghenies.

[b] The value figures for 1820 contain the element of estimate indicated in Chapter IV. The number of firms and the value of output do not include glass-cutting or glass-staining establishments, unless the census descriptions are in error.

[c] The number of firms does not include glass-cutting establishments, but the value figures do since the *Sixth Census* reports only the combined totals used in the table The 1840 total value figure includes the value of output of one glass-cutting firm in Kentucky. It is not clear whether glass-staining plants are included in the totals but the classification is a minor one in any case.

[d] Neither glass-cutting nor glass-staining plants are included in the number of firms and values of output; the value of output of one factory located in Jefferson County, Kentucky, is included in the total figure in the table.

the growing attractiveness of the low cost Pittsburgh coal area. Specifically, New York in 1820 possessed 21 per cent of the glassworks and 19 per cent of the total output. In 1840, however, the comparable percentages were 16 and 14 and in 1860 they were 20 and 14.

The most notable feature of the evolution of the glass industry in New Jersey was the rapid and extensive increase in factories and output between 1820 and 1840. In 1820 the five glassworks in the state produced glass to the extent of only $69,000, which was 9 per cent of the value of the nation's total. But by 1840 twenty-three factories were producing glass products valued at $904,700 — 31 per cent of the national total. This development is probably explained by the peculiar combination of glassmaking advantages then found in New Jersey (cheap and effective wood fuel, superior silica, and easily available transportation), for by 1860 when wood fuel had become more clearly a factor of high cost the trend of growth had been sharply reversed. New Jersey then had seven less glassworks and produced only 14 per cent of the total value of glass made in the United States.

The most significant aspect of the reorientation of the glass industry between 1820 and 1860 lay in the consistent rise of the district west of the Allegheny Mountains. As the wood fuel surrounding the older factories gradually became exhausted and as old firms died out, cheap coal coupled with nearby supplies of excellent sand drew the center of American glassmaking steadily westward. Although the evidence seems to indicate that wood did not become a significant cost handicap until sometime after 1840, the western region had become even at that early date an important glass-producing region.

In 1820 the nine glasshouses in western Pennsylvania, Ohio, and western Virginia produced glass to the value of $181,680. With 27 per cent of all glass factories and 23 per cent of the total output, the western region then ranked a poor second to New England. By 1840 there were in the western district thirty-one glasshouses making 30 per cent of all domestic glass and glassware, but because of an even greater rate of expansion in New Jersey, the latter and not the western section had moved

into the position of primary importance. Twenty years later the western district had become predominant; although the number of glasshouses had declined the value of output had more than tripled.[30] In 1860 30 works in western Pennsylvania, Ohio, Missouri, and western Virginia produced glass products valued at $2,909,543 and constituting 34 per cent of the national total.

Glass production in the two minor areas, Maryland and eastern Pennsylvania, remained relatively unimportant until after 1840. By 1860 Maryland was no longer as glassmaking state and all of the considerable output then recorded for this section was attributable to the remarkable but temporary rise of Philadelphia County, Pennsylvania.

Methods of Manufacture

No general advance in industrial methodology marked the history of American glass manufacture from 1820 to 1860. Indeed, were it not for the fact that this period saw the introduction of glass manufacture by pressing, a most important and far-reaching innovation, it would not be an exaggeration to describe it as completely devoid of significant progress in the art of glass. This applies with greatest force to the processes and techniques of glass forming. In raw materials and preliminary processes there were some improvements. Although they were valuable, these improvements were not of an order of magnitude to distinguish the years in which they occurred.

By 1860 American glasshouse structures and certain of their facilities were generally conceded to be superior to those of Europe. Deming Jarves, foremost historian of the American glass industry in the first half of the nineteenth century, found basis for such opinion in the improvements in glasshouse construction, plant layout and organization, and glass-melting facilities that had taken place by the time he wrote his *Reminiscences of Glass Making*.[31] Frequently small, dimly lighted, crowded, and poorly ventilated in 1812, glassmaking structures

[30] The decrease in number of factories is probably caused by exclusion of secondary glass-processing plants from the totals for 1860.

[31] Jarves, 2nd ed., p. 51. The first edition of this work was published in 1854 and the second in 1865.

underwent little change during the following thirty years. By 1860, however, pressure of competition in the home market had induced substantial improvement. Factory design had been so modified that principal buildings were considerably enlarged, interior layout more efficiently planned, specialization of processes facilitated, and interdepartmental coördination more fully developed.[32]

Changes of some importance had also been made in furnace construction. Although little progress was evident before 1840, subsequent attempts to reduce the cost of melting brought effective innovations.[33] Of greatest consequence was the increase of furnace melting capacity. Exterior dimensions were substantially enlarged and, consequently, the number of pots which could be fired at one blast.[34] This increase in capacity with simultaneous progress in design reduced fuel consumption.

After 1840 some progress was also made in the methods of feeding fuel. As indicated above, the earliest American furnaces were hybrid forms of those then characteristic of English and German glassmaking. With the adoption of coal fuel, flint furnaces tended to revert to the circular English type; only the furnaces for window glass continued to be rectangular like the German. In all cases, however, they were fired directly, through the side, and from the level of the glasshouse floor.[35] This practice was highly disadvantageous, for the constant carrying of fuel to the fire door interrupted the workmen, endangered the pots and the quality of the metal, and made equal distribution of heat impossible.[36] By 1860 the New England Glass Company

[32] Jarves, 2nd ed., p. 56.

[33] Jarves, 2nd ed., p. 56.

[34] "Pittsburgh and the Glass Industry," *American Glass Review,* XLVI (March 26, 1927), 15. In the *Scientific American,* November 21, 1846, there is notice of an improved furnace designed by Jarves himself. The notice said that contrary to current practice this new furnace employed a fireplace and flame chamber that extended not along one side but completely around the enclosed pots. This explanation is somewhat puzzling for all the evidence I have found indicates that the fire chamber, even in the earliest furnaces, was in the center of the furnace and surrounded by pots arranged either in a circle or in two parallel lines.

[35] Jarves, 2nd ed., pp. 112–113; "Progress in Window Glass Manufacture," *National Glass Budget,* XXXIII (September 15, 1917), 1.

[36] Jarves, 2nd ed., p. 112.

had eliminated this difficulty by the installation of an underground feeding device.[37] The Delano furnace, patented a few years before the Civil War and cited by Jarves as an important innovation, fed coal by forcing it up at the bottom of the fire.[38]

A comparison of the records of pots, molds, fuels and raw materials found in glasshouses of 1820 and 1860 reveals little evidence of appreciable technical achievement in these other fundamental factors of glass production. Melting crucibles at the later date still were made primarily from imported clays and laboriously shaped by hand. They differed from those of 1820 only in somewhat greater size and metal capacity.[39]

Between 1820 and 1860 the growing importance of glass manufacture by pressing stimulated attempts to improve the quality and greatly increased the quantity and variety of molds, important factors in the success of the new process.[40] Early molds were customarily made of wood cut by a crude and primarily hand process.[41] Both soapstone and brass were later employed; a further innovation, induced by the high cost of brass, consisted of a mold with a brass shell surrounded by iron. The first United States patent for an iron mold was granted to Joseph Magoun in 1847. Iron, however, did not yield the smooth surfaces necessary in glassmaking and the use of molds fashioned from this material made imperative a separate and expensive finishing operation subsequent to the forming of the article. For this reason iron shaping devices did not become really satisfactory until the introduction of the chilled iron molds of 1866.[42]

As in the case of melting pots and molds, there is little to distinguish the glassmaking fuels and materials of 1860 from those used forty years earlier. Throughout the period all but a few furnaces burned either wood or coal. In 1831 it was reported

[37] Watkins, p. 20.

[38] Jarves, 2nd ed., pp. 112–113.

[39] "Early Glass Making in the State of New Jersey," *National Glass Budget,* XXXVIII (October 7, 1923), 18; Jarves, 2nd ed., p. 113. Missouri clay was used by some western glass manufacturers.

[40] *American Glass Review,* March 26, 1927, p. 15.

[41] Molds were later cut by planers and lathes whenever these tools were available.

[42] "Progress in Mould-Making," *National Glass Budget,* XXIX (June 7, 1913), 11.

that Dr. Dyott's vial and bottle works had abandoned wood and was then consuming not coal but North Carolina rosin.[43] That at least a few other factories experimented with this new fuel seems probable, for in 1846 a survey of flint-glass houses in the United States listed among the fuels used by the nineteen active factories 2800 barrels of rosin.[44] Over the entire period, however, coal steadily gained preference as a glass-melting medium. Although a few factories in New England, probably many factories in New York, and certainly most of the factories in New Jersey continued to fuse and fine by wood fires, the growing number of glassworks in the western region and the more important New England plants burned coal.[45] Moreover, though not established by evidence so far discovered, it seems possible and indeed probable that such glass-producing centers as Philadelphia and New York City adopted coal fuel well before the end of the period 1820–1860. The cheap transportation facilities available to them certainly encouraged a change of this nature.

With the exception of the discovery of a few new sources of supply and some improvement in quality, the constituent materials of American glassware remained unchanged prior to the Civil War. Nor did any fundamental variation from the technique of 1820 mark the steps whereby in 1860 the raw materials were prepared and melted.[46]

Except an increase in specialization of tasks, a few minor improvements in technique, and the introduction of two wholly new types of manufacture, glass-forming methods underwent

[43] *New York Tariff Convention,* p. 124.

[44] *Scientific American,* I (March 26, 1846), quoting data supplied by the New York *Tribune* which, in turn, was based on actual returns made to M. and J. Sweeney, glass manufacturers at Wheeling, and submitted to the Honorable Andrew Stewart, Congressman from Virginia.

[45] I have found no definite statement that the factories of New York state did continue wood burning but it is difficult to see how they could have existed in the wooded area if this had not been so. It is definitely recorded, however, that New Jersey plants did not use coal until after 1855. See Weeks, p. 97; Jarves, 2nd ed., p. 49; Watkins, p. 20; "Glass-Making in New Jersey," *National Glass Budget,* XVI (April 6, 1901), 3.

[46] *Eighty Years' Progress of the United States,* pp. 400–401. By 1860 the excellent sand of Berkshire County, Massachusetts, had been added to the already well known resources near Pittsburgh and in New Jersey.

no great change between 1820 and 1860. Crown glassmaking, probably even of less quantitative importance in 1860 than in 1831, was pursued in the exact manner of 1820.[47] The blower, still working with the assistance of only a tending boy, gathered the same amount of metal on his pipe, marvered it in the same way, blew it out, attached it to the pontil, and manipulated it into a circular disk of approximately the same size. As in earlier years the disks were then placed on edge in an annealing oven; in 1860 they were arranged in rows, supported by iron rods, and kept in the oven from twenty-four to forty-eight hours.[48]

The process, if not all phases of the technique, of cylinder-glass manufacture was also identical with that of earlier days. In 1860 as many as ten workmen labored side by side on a raised platform in front of the furnace and ten feet above the glasshouse floor. Standing upon this, each man gathered metal from the pot before him and worked the resultant lump of glass into a globe by means of a wooden "mold." [49] After reheating the globe, the worker raised the blowpipe vertically above his head and distended the globe by blowing. He then swung the pipe with its adhering glass below the platform on which he stood and resumed blowing. These operations were continued until the cylinder became inflated and elongated to the desired size. It was opened by means either of a hot iron and cold water or a diamond point and was carried to the flattening oven where it was placed on a flattening stone. Here one workman with an iron rod hastened the flattening process, and another worker worked out the irregularities by use of a rod with a block of wood attached to the end. Finally the sheets were annealed and cut.[50]

The only outstanding difference in the essentially similar techniques of cylinder production in 1820 and 1860 appears to lie in the use of the platform.[51] Other sources, however, indicate

[47] See Chapter IV.

[48] *Eighty Years' Progress of the United States,* pp. 401–402.

[49] This mold was actually the marver.

[50] *Eighty Years' Progress of the United States,* p. 402.

[51] I have been unable to establish the date at which the platform construction was first used in the United States. It is possible that it was employed as early as 1820. Neither Gregory's *Dictionary,* American edition of 1822, nor Porter in *Cabinet Cyclopedia,* American edition of 1832, mention such a device.

that a further departure from the practice of 1820, not clearly evident in the above description, had taken place by 1860. Although some blowers as late as 1850 gathered, flattened, and even cut their own "rollers," these separate steps became after 1820 more and more sharply differentiated by a gradual but continuous elaboration of the division of labor. From this process of specialization of tasks arose the four distinct window-glass trades which thereafter characterized the industry as long as window glass was made by hand. The blowers first gave up cutting, then flattening, and finally gathering. Shortly before 1860 many window-glass factories employed the following system. The gathering and actual blowing of the cylinders was performed by the blowers, the most highly skilled of the window-glass workers. Assisting the blowers were tending boys, customarily apprentices. These boys usually put up pipes, kept water in the wooden blocks, carried out "rollers," and helped carry glass from the flattening oven to the cutting room. Some of the blowers, however, allowed their tending boys to gather for them. If this was the case, at the beginning of their training the tending boys made only the first gather. With more experience they were permitted to gather second glass also, but only at the end of three years' training were they entrusted with the final and most difficult gather. The operations of flattening were carried on by a distinct group of workers who employed assistants known as "shove" boys. Cutting, the final step in the making of cylinder window glass, was performed by a third group of workers. Although the flatteners received about one-fifth of the blowers' wage rate, they usually flattened for several blowers at one time and hence their income about equaled that of the latter. The shove boy and the tending boy were paid by the flattener and blower respectively.[52] Although this system of production was still common in 1860, certain factories carried the division of labor even further and regularly employed one or more gatherers for each blower.[53]

[52] "History of the Skilled Window Glass Workers' Trade," *Glassworker,* XXXV (August 11, 1917), 2.

[53] This seems to have been done in certain factories as early as 1820. I have no precise evidence of the extent to which gathering was separately performed in 1860, nor whether it was customarily done by more than one gatherer for each blower.

With the exception of the introduction and development of the new process of pressing, the manipulative technique of glassware manufacture changed but little between 1820 and 1860. Off-hand blowing was done in 1860 as it had been done in 1820. Neither tools nor the manner of using them were altered. Much the same can be said of mold-blown glassware, for improvement and increase of the number and variety of molding devices was largely a legacy from pressing. In part explanation, it may be suggested that both the off-hand and the mold-blowing methods of glass-forming experienced declining significance in glassware manufacture; the introduction of pressing brought about a veritable revolution in that branch of the industry.[54] Indeed, one contemporary description of the manufacture of "flint glass for domestic purposes" in 1860, does not even mention any glass-fashioning process other than pressing.[55]

Although there was no technical advance in the blowing of glassware, in the larger factories at least division of labor in the forming operations appears to have been elaborated. Watkins, for example, describes the organization of the production units at the New England Glass Company in 1856 as follows: "The glassblowers worked here [main building of the factory] in little groups known as 'shops,' consisting of a gaffer or foreman who finished the work, a 'servitor,' or helper, under him, who did the actual blowing, and two boys who assisted the more experienced workmen."[56]

The history of bottle manufacture after 1820 is marked by a few relatively minor though not wholly unimportant improvements. One of the first, the introduction of the "push up" or sham bottom, enabled bottles to stand firmly in an upright position. A more important change, occurring about or sometime after 1825, caused the heretofore customarily used common green and amber bottle metal to be replaced by clear flint. In this same period bottles also began to be made with a heavier lip.[57] No further improvement seems to have taken place until

[54] Jarves, 2nd ed., p. 85.

[55] *Eighty Years' Progress of the United States,* p. 404.

[56] Watkins, p. 24.

[57] "History of Glass-Making: American Glassware for Drinking Purposes," *Glass Container,* VI (November 19, 1926).

shortly before the Civil War.[58] Between 1850 and 1860 the pontil mark, an identifying feature of early bottles, disappeared. This was the result of the development of the "snap" process of holding bottles during the finishing. The older method had been to attach to the bottom of the bottle a pontil which when broken off left a rough scar; the device hereafter employed, a holding apparatus, left no mark whatsoever. About the same time it became customary to add to the mouths of bottles a rim or beading, formed by an instrument known as a "tool." [59] It will be remembered that early bottles had irregular and unmodified sheared mouths.

The introduction and development of glass manufacture by pressing was the outstanding technical innovation of the period 1820–1860. Frequently said to be an American discovery and credited by different writers to various individuals and factories in the United States, pressed glass actually originated in Europe.[60] Deming Jarves points out that the process was known and practiced in both Holland and England long before it was introduced here. He says, "Fifty years back [1815] the writer imported from Holland salts made by being pressed in metalic moulds, and from England glass candlesticks, table centre-bowls, plain, with pressed square feet, rudely made, somewhat after the present mode of moulding glass." [61]

The first use of pressing was formerly attributed to the famous factory at Sandwich, Massachusetts, but evidence recently presented indicates that the New England Glass Company was making glass products by this method as early as 1820. Not until after 1825, however, was there any widespread commercial interest in the process. On October 16, 1827, P. C. Dummer of Jersey City took out a patent for a glass-pressing mold. This was also the year that Deming Jarves and the legendary Sandwich

[58] Walbridge, p. 67, intimates that in the 1840's it became customary to apply to the mouths of bottles a laid-on ring of glass.

[59] *Glass Container,* November 19, 1926; Barber, p. 19.

[60] Jarves, 2nd ed., p. 93; "Epochs in Glass-Making," *National Glass Budget,* XXI (December 9, 1905), 1; "Pressed Glass Industry," *Commoner and Glassworker,* XXIII (August 9, 1902), 6; "First Pressed Tumbler," *Commoner and Glassworker,* XXIII (January 18, 1902), 18; "Continuous Tank Furnaces," *National Glass Budget,* XXIV (January 22, 1909), 1.

[61] Jarves, 2nd ed., p. 93.

carpenter were said to have devised and first utilized a rude pressing machine. Later, on December 1, 1828, Jarves obtained a patent for a "method of pressing melted glass into moulds." [62] Once the mechanical method was established, pressing became increasingly important in the production of American glassware. Gradual improvement of the machines and details of working them hastened the rate at which it gained prominence.

From about 1830 to 1845 the pressed-glass industry made slow progress; production during these years was marked by extensive experimentation and a severe struggle with foreign and domestic blown glassware.[63] But by 1860 much had been achieved. Pressing had revolutionized the flint-glass industry. Jarves estimated in the 1865 edition of his *Reminiscences of Glass Making* that over three-fourths of the weekly flint "melt" was pressed. More than $2,000,000 had been invested in molds and machines for this process.[64] He had pointed out earlier that pressing so reduced flint-glass costs that the consumption of such articles had multiplied tenfold.[65]

The general nature of the glass pressing process is excellently summarized in the following sentences:

> [Pressed glass] is, strictly speaking, one form of cast glass, the molten metal being gathered and cast in a mold which would correspond with the table of the plate-glass works, the plunger of the press answering to the roller. There are, however, so many and important variations in the methods of pressing as to justify its classification as a separate process . . . As usually practiced a metallic plunger is driven into a metallic mold into which molten glass has been placed by mechanical means, the glass taking the form of the mold upon its outer surface, while the inner is modeled by the plunger itself. The simplest form of mold is a flat slab of . . . metal with slightly raised sides. For articles of some complexity molds are made in two or more divisions, hinged together (joint molds), and opening outward. The chief parts of the mold are termed the "collar" and the "base" . . . The molten glass having been gathered and dropped into

[62] Watkins, pp. 84–87, 89.

[63] "Some Domestic Glass Lore," *National Glass Budget,* XVIII (December 27, 1902), 1.

[64] Jarves, 2nd ed., pp. 85, 94.

[65] Jarves, 1st ed. (1854), p. 49.

the mold, a sufficient quantity is cut off, the mold is pushed under the plunger, and the long lever . . . pulled down. The plunger enters the mold, the glass is pressed into all parts of the same, the plastic mass solidifies, the plunger is withdrawn, the mold opened, and the glass in the required form is withdrawn . . . If too much glass is cut off, the article is too thick; if too little, it fails to fill the mold, and the article is spoiled. Though this is quite a simple operation, and though as great skill as in the old method of glass-blowing is not required, considerable practice is still necessary to gather the right amount of metal and to cut if off so as not to waste glass, and also to keep the mold at the right temperature. If it is too hot, the glass will adhere to the die and plunger; if too cold, the surface will not be clear and transparent.[66]

[66] Weeks, p. 47. Before 1860 pressing was not considered glassmaking nor pressers glassmakers. The workers employed were often intelligent but unskilled laborers drawn from the men in the glasshouse yard.

An interesting supplement to the above description, a contemporary exposition of the details of working and the labor organization employed, is contained in the following excerpts from Hunt's *Merchants' Magazine and Commercial Review* (XV [October, 1846], 418; XXIV [January 22, 1909], 1), the first explaining the manufacture of pressed tumblers and the second that of pressed glass bowls.

"In the first place, the workmen have a brass mould, consisting of a solid mass, about as large over as a half-peck measure, containing a hollow in it exactly of the form of the tumbler to be made, with a follower of brass of the same form, but so much smaller as to fit the inside of the tumbler. When the two parts of the mould are put together, the space between them is the exact thickness of the vessel required. In the process of manufacturing, three men and two boys are required. The first thing done, is for one of the men to dip an iron rod in the melted glass, and move it about until he has a sufficient quantity of the fluid mass on the end of his rod; he then holds over the hollow of the mould, and, with a pair of shears, cuts off what he judges to be just enough to constitute the tumbler. Instantly the other man brings down the follower with lever power, and the melted glass is so compressed as to fill the cavity of the mould. He then turns his mould bottom up, with a little blow, and the tumbler drops red hot upon the stone table. One of the boys, with an iron rod having a little melted glass on its end, presses it on the bottom of the tumbler and it slightly adheres. He then holds it in the mouth of a glowing furnace, turning it rapidly, till it is almost in a melted state, when the third man takes it, and whirling the rod and tumbler on a sort of arm of a chair, he holds a smooth iron tool against the edge of the tumbler, till all the roughness is removed from its edges, when a boy takes the rod from him, and, by a slight stroke on the end of it, drops the tumbler, and places it in a hot oven to cool gradually. These five hands will make a beautiful tumbler in about forty seconds, or about one hundred in an hour."

The second quotation is of particular interest since it describes glass-pressing

Although European glassmakers held legitimate claim to the origin of glass forming by pressing, the greatest contributions to the art were undoubtedly made by mechanics and glass manufacturers of the United States.[67] Between 1814 and 1838 Holland and England made no improvement in the process they introduced and used it only for the production of common-glass salts and glass in square feet. The lead taken by America found expression in continual mechanical and general technical innovations, and though many of the more important of these came after the Civil War, progress made by 1860 placed the American pressed-glass industry far in advance of the industry in Europe.[68]

The first plate glass manufactured in the United States was probably made at Cheshire, Massachusetts, in 1852 or 1853. There is, however, some evidence of previous attempts at Williamsburg and Green Point, New York, between 1850 and 1852, and it is even possible that insignificant amounts were made earlier in some of the older window-glass factories. In 1852 or 1853, a Cheshire window-glass factory was remodeled for the

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at the well-known Boston and Sandwich Glass Company plant during the earlier years of the concern's career: "We witnessed at the factory of the Boston and Sandwich Glass Company, the making of glass bowls by machinery, and of a magnitude that far exceeds in size and weight any heretofore made in this or any other country. The machine, we understand, weighs between two and three tons, and is worked with the accuracy of a steam engine. The glowing metal was taken from the furnace at its greatest fusion by the workmen, placed in the machine by hand, set in motion, and in a few minutes a perfect bowl, of rich design was turned out, spreading a most intense heat around, which, none but those accustomed to the business could stand. It was an interesting sight to notice the arrangement made in working the machine — there is no confusion — each workman is in his allotted place — and it surprises us to see an article of its weight and size handled with so much judgment and skill, that in one minute it was taken from the press by the head workman, and carried to a side furnace to receive the fire polish, and formed into shape; as soon as that was secured, it was taken to an annealing kiln, and placed therein to cool — which requires eight or ten days. The bowl, we learn weighs about sixty pounds, stands twenty-one inches high and twenty-two inches in diameter at the top. It is called the Union Bowl, and the moderate price it is held at will enable hotel keepers and others to possess a beautiful and useful center ornament for their table."

[67] *National Glass Budget,* December 9, 1905, p. 1; *National Glass Budget,* January 22, 1909, p. 1.

[68] Jarves, 2nd ed., p. 94.

manufacture of rough cast-plate. Despite installation of expensive tools and machinery it operated only six months before being moved to Brooklyn, New York. The new factory produced only a small quantity of salable glass and in 1856 was abandoned.[69]

A second effort was made at Lenox Furnace, Massachusetts. In 1855 inactive glassworks owned by a group of Lenox iron manufacturers was leased to James N. Richmond, organizer of the National Plate Glass Company. This company spent large sums of money in reorganizing the factory, installing the much-moved tables and tools of the Brooklyn concern, and in experimentation, but nevertheless failed with heavy loss in 1856. The factory, upon reversion to the original owners, was operated by them until 1865. In 1860 the output of this works, rough plate only, was valued at $30,000, an insignificant portion of total domestic consumption of this type of glass.[70]

The process of casting plate glass required less skilled labor than any other process of glassmaking save pressing. Jarves in 1854 commented that since "materials are cheaper than in Europe, and as the most essential part is performed by machinery and motive power" it was surprising that American glassmakers had not earlier and more effectively exploited the field.[71] The explanation apparently lay in ignorance of the essential details of the process, the necessity of importing all the machinery from England, the large capital investment required, and the preoccupation of American glass manufacturers with other and better understood branches of glassmaking.

After 1820 the variety of products made in the glasshouses of the United States became so great that it would be futile to attempt to enumerate them. It is worthwhile, however, to sketch the broad outlines of the various classes and types. The outstanding change in the nature of glass objects made between 1820 and 1860 was the great increase in the use of flint. This was largely attributable to the development of pressing; most glassware made by this process before and during 1860 was

[69] Weeks, p. 98.

[70] Weeks, p. 98; *Eighth Census.*

[71] Jarves, 1st ed., p. 41.

composed of such metal.[72] Quantities of tableware streamed from American presses, also other types of glass used in the home — toilet articles, candlesticks, and chandeliers, for example.[73] It is said that Thomas Leighton and his sons, of the New England Glass Company at East Cambridge, were so successful in the pressing of large and heavy druggists' goods, chemical wares, and "philosophical apparatus" that they "monopolized" this branch of the industry.[74] The finest workmen and factories made pressed flint in imitation of the more expensive cut glass with sufficient excellence to require, according to Jarves, an expert to distinguish the two.[75] And there was yet another reason for the increased importance of flint glass; after 1825 bottles and containers which formerly had been fashioned from green and amber metal came to be made more and more frequently from flint.

During the forty years subsequent to 1820 the blowing branch of the glass industry continued to produce fine glassware for various uses, black bottles, great quantities of bottles and containers, and, of course, window glass.[76] Important new products made in 1860 included plate glass and glass chimneys. Though the latter had earlier been made in limited quantity (particularly after 1834), the discovery of petroleum shortly before the Civil War tremendously stimulated their production.[77] By 1860 the glass industry had felt the first exhilarating effects of this development. Chimneys then, and for many years afterward, were blown off-hand.[78]

[72] Jarves, 2nd ed., pp. 85, 93–94; "American Pressed Glassware," *National Glass Budget,* XXV (February 19, 1910), 1.

[73] Watkins, pp. 84–106.

[74] Jarves, 2nd ed., p. 95.

[75] Jarves, 2nd ed., p. 85. In addition to the Leightons, other notable figures in pressing were Thomas Bakewell, James B. Lyon, William Phillips, William Best, and John Adams of Pittsburgh, and John L. Gillerland of Brooklyn ("Some Domestic Glass Lore," *National Glass Budget,* XVIII [December 27, 1902] 1; Jarves, 2nd ed., p. 96).

[76] Production of fine and ornamental glassware in the United States was not large; much was imported. See *Scientific American,* VI (October 26, 1850), 45.

[77] "The Lamp Chimney Industry," *National Glass Budget,* XXVI (April 29, 1911), 1.

[78] "Historical Data About Glass," *National Glass Budget,* XVII (August 10, 1901), 1.

THE STATUS OF LABOR

Labor history of American glassmaking between 1820 and 1860 is fragmentary. That more is not known may perhaps be taken as evidence that the economic fate of glassworkers in these forty years was not a particularly unhappy one. By 1860 both the number and the skill of workers in the glass industry of the United States had appreciably increased. Workers reported by the Census of 1820 totaled 985; in 1860 the figure was 8871.[79] This augmentation of numbers no doubt came both from continued immigration and the widening ranks of American apprentices. Moreover, forty added years of experience, training, and competition made the glass blower and glassworker of 1860 a more deft and able craftsman than his counterpart of 1820.[80]

As in 1820, there is little available information during the following forty years on the nature and extent of workers' control over hours, output, and apprenticeship. In general it seems to have been customary for each manufacturer to make individual arrangements with his employees. There existed no national or regional unionization of any importance and such local agreements as may have been made from time to time had no appreciable effect upon conditions in other areas.[81] That glassworkers did in some degree influence the determination of hours of labor, quantity of output, and number of apprentices indentured is not to be doubted. Jarves' complaint certainly bespeaks such action. He says, "There is no mechanical branch of industry offering such advantages for the full manifestation of a workman's real skill and industry, if the conventional usages which restrict the work could but be abrogated, — usages tending to a limited amount of work, and consequently making the

[79] *Fourth Census; Eighth Census.* The figure for 1820 includes one estimated item only, computed on the basis of employment of firms of similar size.

[80] Jarves, 2nd ed., p. 32.

[81] "Sketch History of Glass Bottle Blowers' Association," *Commoner and Glassworker,* XXII (July 13, 1901), 3; "Flint Glass Organization, History and Progress," *Commoner and Glassworker,* XXIV (October 18, 1902), 3. For an exception in the case of the glass-bottle blowers, see Chapter VII. The exception applies only to the very end of the period 1820–1860, however.

workman to realize but a limited amount per week. Such workmen, of all others, should be allowed the inherent and inalienable right to work as long, and at such times, as the individual may deem for his comfort and interest." [82]

Despite the absence of the powerful and inclusive labor organizations that dominated the history of glassmaking after the Civil War, the bargaining position of the American glassworker, strong in 1820, remained so in 1860. Wages of course constitute the logical and most direct evidence to be submitted in support of this statement. Unfortunately data on actual payments made to glassworkers between 1820 and 1860 are not only rare and incomplete, but also frequently incomparable. Such of the existing statistical records as may be reduced to a common basis, however, indicate that wages in both the eastern and western glassmaking sections of the country rose during the greater part of the period. That they were higher at the end of the interval than at the beginning is well established.[83] Two contemporary appraisals of the status of skilled glassmakers' wages shortly before 1860 are of interest. Jarves, writing in 1854, reported that "there is no mechanical employment in this country yielding so good returns to the industrious, as a good worker in glass, of the present day, can secure in the exercise of his skill." [84] George W. Carter, intimately familiar with the workers of the New England Glass Company, declared that shortly before the Civil War the glass blowers employed by this firm were the most prosperous members of their community. Their wages were very high, "amounting to as much as nine or ten dollars a day." [85] However, in the new branch of American glassmaking,

[82] Jarves, 2nd ed., p. 102.

[83] These statements rest upon comparison of the data in the following sources: "A View of Pittsburgh," *Commoner and Glassworker*, XXIII (May 31, 1902), 7; Watkins, p. 26; McLane, *Report on Manufactures*, II, 523–527; Massachusetts Bureau of Statistics of Labor, *Seventh Annual Report* (1885), p. 161; *The British Mechanics and Labourer's Hand Book, and True Guide to the United States* (1840), p 252; *Niles' Weekly Register*, LXX, 127; Department of Labor, Bureau of Labor Statistics, *History of Wages in the United States from Colonial Times to 1928* (1929), p. 233, hereafter cited as *History of Wages in the United States.*

[84] Jarves, 1st ed., p. 56.

[85] Watkins, p. 157. The quotation is from Watkins.

pressing, wages were lower than in other divisions of the industry.

Throughout the period 1820–1860 wages in the American glass industry continued to be higher than those paid abroad. In 1831 cost of labor in the United States was said to be "double the amount paid in England, and three times the amount paid in Germany for making the same quantity." [86] Another source also states that before 1860 wages here were higher than those paid in England.[87] Jarves says that "the glass-maker is paid, at least three times the wages usually paid in Germany or France," and again that "the wages of glass-makers in this country are in about the ratio of two and a half to one of those paid on the continent." [88]

The Course of Prices

All branches of the American glass industry appear to have experienced falling prices between 1820 and 1832. There is ample evidence that flint-glass prices had decreased by 1831. In that year the Committee on Glass of the New York Tariff Convention reported that "the improvements made in the art, the increased skill of the workmen, and the regularity of the demand, have enabled the manufacturers to meet the present reduced prices (which are fully one-third less than in 1816)." It also reports elsewhere that "the price of glass was . . . [before 1812] nearly fifty per cent higher than at the present day." [89] The flint-glass factories submitting data for the McLane Report on Manufactures made similar statements. One pointed out that there had been a gradual decline of prices for several years. Another declared that since 1808 flint prices had fallen from $33\frac{1}{3}$ to 50 per cent and attributed this fall to decreased costs resulting primarily from increased skill, use of machinery, and employment of apprentices.[90] A few years earlier, in 1828, more detailed evidence had been presented to the House Committee

[86] *New York Tariff Convention,* p. 127.

[87] "Historical Data About Glass," *National Glass Budget,* XVII (August 10, 1901), 1.

[88] Jarves, 1st ed., pp. 54, 56.

[89] *New York Tariff Convention,* p. 123.

[90] McLane, *Report on Manufactures,* II, 523–527.

on Manufactures. Benjamin Bakewell, flint manufacturer of Pittsburgh, testified before the committee that common half-pint tumblers sold in 1808 for $2.00, shortly after 1820 for $1.00, and in 1828 for $.81 a dozen. Prices of plain quart decanters and wine glasses showed similar trends. Decanters brought $6.00 a dozen in 1808 and twenty years later only $2.25; wine glasses which in 1828 were worth only $.75 a dozen had been valued in 1808 at twice that amount.[91]

Between 1830 and 1860 the introduction and development of pressing in the flint-glass trade greatly affected prices.[92] Jarves says at one point that "the articles of flint-glass imported by the earthenware trade [in 1812] were confined to a very few articles, such as German straw tumblers, cruets, salts, and plain decanters of cheap fabric; of the finer articles, to cut finger tumblers, sham diamond cut dishes, and Rodney decanters; a quality of glass and cutting that would not at the present day command one-fifth of their then cost."[93] This statement seems applicable not only to pressed flint but to blown flint as well. The following statement, on the other hand, clearly relates only to pressed-flint products: "The tendency, in this particular [the introduction of pressing], has been so to reduce the cost of glass that it has multiplied the consumption at least tenfold; and there can be no reasonable doubt but that, at this period, a much larger quantity of flint-glass is made in this country than in England."[94]

Such window-glass price quotations as are available for the period 1820 to 1860 are difficult to interpret because of the frequent omission of identifying specifications; for example, prices of glazing glass varied not only with the dimensions of the "lights," or panes, but also with the quality and thickness of the panes. There was, furthermore, a noticeable disparity between eastern and western quotations, particularly in the earlier years. The last circumstance causes comparisons at dif-

[91] *American State Papers: Finance* (1859), V, 778.

[92] I have found prices for a long list of articles made at the "Flint Glass Works at Boston" but cannot use them effectively because comparable earlier and later quotations are missing.

[93] Jarves, 2nd ed., p. 59.

[94] Jarves, 2nd ed., p. 86.

ferent time intervals to be misleading unless the prices are for the same production area.

In 1824, according to a Philadelphia quotation, window glass 8 x 10 inches in size and of a quality equal to the imported glass sold at $6.50 a box of a hundred square feet.[95] Four years later a window-glass manufacturer of the District of Columbia, Andrew Way, testified before the House Committee on Manufactures that his 6 x 8 and 7 x 9 sizes of glass sold in New York City at an average price of $5.50 a box. He also said that glass of the best quality in the 8 x 10 size brought $8.00 a box at Baltimore and Washington and second quality glass brought $6.50; in other markets both grades rarely sold above $5.50 to $7.00 a box. Larger sizes, 9 x 11 and 10 x 12, customarily enjoyed a differential of from fifty cents to a dollar above the 8 x 10 prices. Benjamin Bakewell, testifying before the same committee, reported Pittsburgh window-glass prices to be $3.00 to $4.00 for a box of 8 x 10 and $4.75 to $5.00 for 10 x 12.[96] Mathew Carey in 1829 wrote that window glass "is now sold at five dollars, of the best quality." [97]

If the cylinder window-glass quantity and value totals in the glass report of the New York Tariff Convention are statistically appropriate to one another, the average price per box of cylinder glass in 1831 was $4.90.[98] This price should be described as one for "average" quality, size, and thickness.

The prices reported by the western window-glass houses in the McLane report of 1832 are considerably lower than the prices given above for the East. This difference was not attributable, however, to a different box capacity, for one of the plants reporting low prices specified the hundred-foot box. A firm in Fayette County, Pennsylvania, said the price of a box of 8 x 10 glass, quality not described, was $4.00. Another mentioned only that the box price was then $3.62½. Two firms called attention to falling costs and one of the two reported that since 1827 costs had decreased by 10 per cent and materials by six per cent. An-

[95] *Niles' Weekly Register,* XXVI, 3.
[96] *American State Papers: Finance* (1859) V, 778.
[97] Mathew Carey, *Common Sense Addresses* (1829), p. 31.
[98] *New York Tariff Convention,* p. 126.

TABLE 5

PRICES OF AMERICAN WINDOW GLASS AT NEW YORK, 1825–1863

Year	Lowest	Highest	Average
1825	$6.00	$6.75	$6.04–6.31
1826	6.00	6.50	6.00–6.48
1827	6.00	6.25	6.00–6.25
1828	6.00	6.25	6.00–6.25
1829	6.00	6.25	6.00–6.25
1830	6.00	6.25	6.00–6.25
1831	3.00	3.12	3.00–3.12
1832	3 00	3.12	3.00–3.12
1833	3.00	3.12	3.00–3.12
1834	2.75	3.00	2.75–3.00
1835	2.25	2.75	2.44–2.66
1836	2.25	3.00	2.58–2.79
1837	2.75	3.00	2.75–3.00
1838	2.75	3.00	2.75–3.00
1839	2.75	3.00	2.75–3.00
1840	2.75	3.00	2.75–3.00
1841	2.75	3.00	2.75–3.00
1842	2.75	3.00	2.75–3.00
1843	2.75	3.00	2.75–3.00
1844	2.75	3.00	2.75–3.00
1845	not reported	..	.. ..
1846	not reported	..	.. ..
1847	2.62	3.50	2.62–3.50
1848	2.62	3.50	2.62–3.50
1849	2.62	3.50	2.62–3.50
1850	2.62	3.50	2.62–3.50
1851	2.62	3.50	2.62–3.50
1852	2.62	3.50	2.62–3.50
1853	2.50	3.25	2.50–3.25
1854	2.50	3.50	2.50–3.25
1855	2.50	3.25	2.50–3.25
1856	2.50	3.50	2.54–3.29
1857	2.75	3.75	2.82–3.57
1858	2.75	3.75	2.87–3.62
1859	2.75	3.50	2.75–3.50
1860	2.75	3.50	2.75–3.50

TABLE 5 (Continued)

Year	Lowest	Highest	Average
1861	$2.75	$3.50	2.75–3.50
1862	2.75	3.75	2.77–3.52
1863	3.25	6.25	3.98–5.37

Data from House of Representatives. *Executive Documents* (1864), VI, 38 Cong , 1 Sess., p. 272. No size, quality, or thickness specified; box of 100 sq ft , 1825–1830; box of 50 sq. ft., 1831–1863. See Table 6 for comparable average prices at Philadelphia.

other firm, on the contrary, said costs of materials had increased. Still another firm reported that costs had not fallen in proportion to prices. Two more firms stated that the 1832 price was $4.00 a box and a third quoted $3.50 to $4.00, with no specification of size, quality, or thickness.[99]

Window-glass price quotations for the years following 1832 are drawn solely from eastern markets. Table 5 shows prices of American window glass in New York City from 1824 to 1863, and comparable average prices in Philadelphia from 1835 to 1849 are included in Table 6. The manner of quotation of the New York prices is unfortunate. No explanation is given of size, quality, or thickness, and the way in which the average price is stated is in itself confusing. Despite these liabilities, the figures may be used as indicators of trend since it seems reasonably safe to assume that they are comparable among themselves. Prices of the various sizes of window glass at Philadelphia between 1835 and 1849 appear in Table 6; here, there is definite statement of specifications. The compilers of the data for this table reported that they did not include sizes greater than 12 x 18 inches because domestic glass above these dimensions was seldom blown in 1835 and seldom sold in 1847 because of the lower cost of the imported product.

Interpretation of the window-glass price data summarized above is hazardous and no precise conclusions can follow. It may be said with some confidence, however, that window-glass prices fell in the western producing area between 1820 and 1832.

[99] McLane, *Report on Manufactures,* II, 527–532.

Both the prices quoted and the comments made by the firms reporting to McLane suggest this conclusion. They also may have declined slightly in the East within this period but the evidence here is not clear. The general trend of the New York quotations from 1831 to 1860 is undoubtedly downward. The movement, however, is by a stair-step process which shows di-

TABLE 6

PRICES OF AMERICAN WINDOW GLASS AT PHILADELPHIA, 1835–1849

Year	8 x 10 inches	10 x 12 inches	10 x 14 inches	12 x 18 inches	Average
1835	$2.37	$2.37	$3.09	$3.56	$2.85
1836	2.49	2.49	3.09	3.56	2.91
1837	2.36	2.48	2.93	3.37	2.78
1838	2.23	2.46	2.90	3.35	2.73
1839	2.22	2.35	2.87	3.19	2.66
1840	2.23	2.35	2.87	3.19	2.66
1841	2.05	2.26	2.76	3.07	2.53
1842	1.87	1.96	2.40	2.67	2.22
1843	1.83	1.92	2.36	2.62	2.18
1844	1.80	1.90	2.30	2.57	2.14
1845	1.70	1.79	2.19	2.44	2.03
1846	2.06	2.25	2.44	2.81	2.39
1847	1.92	2.10	2.28	2.63	2.23
1848	1.79	1.95	2.11	2.44	2.07
1849	1.65	1.80	1.87	2.16	1.87

Data from *Reports* of the Secretary of the Treasury of the United States (1851), VII, 608. Glass of medium quality, 80 to 100 lbs. per 100 sq. ft.; box of 50 sq. ft. It is not definitely stated that the quotations applied to a 50-foot box but comparison with the New York figures (see Table 5) proves that this must have been so. Comments accompanying the table when submitted support this contention.

vergences both between the levels of the high and low figures of the average, and between the highest and lowest quotations (the higher prices recorded from 1825 to 1830 are of no trend significance since they are quotations for a box of a hundred square feet instead of fifty; the latter seems to have come into common use shortly after 1830). The Philadelphia average prices are derived from the differentiated data of Table 6. They indicate not only a more consistent decline but also that the New

York prices must have been quotations for larger sizes or better quality than those at Philadelphia, for the New York prices vary on a considerably higher level, particularly after 1842. The four individual series in Table 6, like their average, show declining trends.

There is evidence that prices of common glassware also declined between 1820 and 1832. The report of the New York Tariff Convention stated that "prices have been reduced fully

TABLE 7

PRICES PER GROSS OF DOMESTIC VIALS, 1812–1832

Kind of vial	1812 and before	1815–1818	1819–1822	1824–1827	1828–1829	1830–1832
Assorted	$7.00	$3.50	$3.00	$2.50	$2.25	$2.00
½ and 1 drachm	8.00	4.00	3.50	3.00	2.70	2.40
½ and 1 ounce	5.50	3.00	2.50	2.00	1.80	1.60
1½ and 2 ounces	6.00	3.00	2.50	2.25	2.00	1.80
3 ounces	6.50	3.00	2.50	2.50	2.25	2.00
4 ounces	7.00	4.00	3.25	2.87	2.60	2.30
6 ounces	7.50	4.00	3.25	3.25	3.00	2.60
8 ounces	8.00	4.00	3.25	3.50	3.30	2.80

Data from Dyott, p 53.

fifty per cent and the quality of the ware is at least equal, if not superior, to the foreign manufacture."[100] Table 7, reproduced from a more extensive table found in Dyott's *System of Moral and Mental Labor,* demonstrates the decline of prices in vial manufacture, an important subdivision of common-glass production. With the development of pressing, an increasing number of articles formerly made of common glass came to be fashioned from flint. Consequently, production of common glassware in the latter half of the period 1820–1860 was composed largely of bottles and containers. Information is insufficient to permit any approximate statement as to the course of these bottle, vial,

[100] *New York Tariff Convention,* p. 124.

CHAPTER VI

TARIFF POLICY AND ITS CONSEQUENCES, 1820–1860

A General Outline of Tariff Policy

Although import duties on foreign glass and glassware were gradually increased by the series of acts which followed the tariff of 1789, except in the war period of 1812 the general level was never higher than 22½ per cent and even the ad valorem equivalents of the specific duties on black bottles and window glass seem not to have been substantially greater. Before 1820, if we judge by later standards, no branch of the American glass industry received more than moderate tariff protection. Between 1820 and 1860 the degree of tariff protection fluctuated sharply. First came a period of heavy protection lasting from 1824 to 1832, then an era of increasing moderation culminating in the short-lived 20 per cent level of 1842. In that year a strong protective policy was again instituted but this came to an end in 1846. The years 1846–1857 constituted another period of moderate protection and 1857–1860 a period of still lower duties.

The duties levied by the tariff act of 1824 were in form both specific and combined specific and ad valorem.[1] Window glass was taxed according to the three size groups of 1816. The average specific duty for these three classifications, $3.50, represented an increase of 24 per cent over the comparable figure in 1816, $2.83.[2] This act was the first to provide that all window glass imported in uncut plates should be dutiable at the maximum rate specified. In 1816 only one class of common glassware, black bottles, had been charged with specific duties. In 1824 three were so taxed, black bottles, vials, and demijohns. The

[1] *Tariff Acts*, p. 78.

[2] The individual duties per box of 100 sq. ft. were as follows:

Not above 8 x 10 inches	$3.00
Above 8 x 10 inches, not above 10 x 12 inches	3.50
Above 10 x 12 inches	4.00

rate on black bottles now varied according to capacity from \$2.00 to \$3.00 a gross, an average of \$2.50.[3] The new duty on the quart size was 39 per cent greater than the rate of 1816. Demijohns, for the first time especially provided for, carried a rate of \$.25 each. Vials were charged at either \$1.00 or \$1.25 a gross depending upon capacity.

Two other rates provided in 1824 covered imports of all other glassware. Cut glass, which in 1818 had been made dutiable at 30 per cent, was dutiable at 30 per cent plus an additional \$.03 per pound. Glass imports not specifically designated were treated similarly; in addition to the 20 per cent duty imposed by the tariff of 1816 they were charged at \$.02 per pound.

The next revision of the tariff, in 1828, augmented two of the increases of 1824.[4] Vials six ounces or less in capacity were now taxed at \$1.75 a gross, but those between six and eight ounces continued at \$1.25. The average specific duty on vials thus became \$1.50 instead of \$1.125, the average under the provisions of the earlier act. The other increase affected window glass; sizes above 10 x 15 inches were dutiable at \$5.00 instead of \$4.00 per box. Because of this increase the average specific duty on window glass was raised from \$3.50 to \$3.875 per box. Other duties remained unchanged.

The tariff act of 1832 did not alter the rates on demijohns, cut glass, or "all other" glass.[5] The specific duties on vials, however, were heavily increased and the range of classification broadened. The average duty for apothecaries' vials and bottles became \$2.00 a gross and for perfume and fancy vials \$2.875.[6] The only

[3] The individual duties per gross were as follows:

Not above one quart	\$2.00
Above one quart, not above two quarts	2.50
Above two quarts, not above one gallon	3.00

[4] *Tariff Acts*, p. 85.

[5] *Tariff Acts*, p. 95.

[6] The individual duties per gross were as follows:

Apothecaries' vials and bottles	
Not above 6 ounces	\$1.75
Above 6 ounces, not above 16 ounces	2.25
Perfume and fancy vials and bottles	
Not above 4 ounces	2.50
Above 4 ounces, not above 16 ounces	3.25

alteration in the window-glass duties reduced the third bracket rate to the level of 1824: sizes over 10 x 12 (and not over 10 x 15 as in 1828) were dutiable at $4 instead of $5.00. A further change affected black bottles; those over two quarts were charged at $2.50 a gross, not $3.00 as in the tariff of 1824.

The Compromise Act of 1833 affected no specific modification of the prevailing duties.[7] It did make provision, however, for gradual general reduction. Successive tenths of the amount by which each duty exceeded 20 per cent were removed at two year intervals from 1834 to 1840. In January 1842 one-half of the residual excess was eliminated and in July the remaining portion. Thus on June 30, 1842, the tariff on glass, as on all other commodities, had fallen to a general level of 20 per cent.

The tariff of 1842 not only restored heavy protection but also revised the technique by which this end was achieved.[8] The specific duties on window glass henceforth were stated in cents per foot and stipulated for six different sizes instead of three. The rates imposed on imports of cylinder window glass varied from $.02 a square foot for 8 x 10 to $.06 for sizes over 18 x 12. On crown glass the range of variation for the same sizes was from $.035 to $.10 a square foot.[9] Furthermore, for the first time in any tariff act, cognizance was taken of variation in the thickness of window glass; all cylinder glass weighing over 100 pounds per 100 square feet and all crown glass over 160 pounds per 100 square feet was charged additional duty at the same rate. These changes compared with the duties of the act of 1832 were as follows: the duty on sizes up to 10 x 14 was reduced by an average of 24 per cent; on 16 x 11 it remained unchanged; the duty on sizes larger than 16 x 11 was increased by an average of 37½

[7] *Tariff Acts,* p. 109.
[8] *Tariff Acts,* p. 120.
[9] The individual duties per sq. ft. were as follows:

	Cylinder	Crown
Not above 8 x 10 inches	$.02	$.035
Above 8 x 10 inches, not above 10 x 12	.025	.05
Above 10 x 12 inches, not above 14 x 10	.035	.06
Above 10 x 14 inches, not above 16 x 11	.04	.07
Above 16 x 11 inches, not above 18 x 12	.05	.08
Above 18 x 12 inches	.06	.10

per cent; the rates on the 8 x 10 and 10 x 12 sizes were reduced below the level of 1816 and the rate on 14 x 10 reduced to slightly above the provision of the tariff of 1816. These innovations were all applicable to cylinder window glass. The new duties on crown glass represented a heavy increase on all sizes.

Fewer and less important changes were made in the common glassware classification. The duties on vials with one minor exception were allowed to remain as they stood in 1832.[10] The duties on bottles, however, were no longer restricted to compositions of black metal. Black and green bottles and jars were made dutiable at an average figure of $3.50 a gross;[11] the comparable rate of 1832 had been $2.25. The specific duty on demijohns (and, in this tariff act, carboys also) was graduated according to capacity. The average duty on sizes varying from one-half gallon to above three gallons amounted to $.32 instead of the formerly prevailing rate of $.25.[12]

In the act of 1842 the duties on "all other" glass and glassware were specifically and elaborately defined. Pressed glass for the first time received recognition in the tariff laws. All articles, plain, molded, or pressed, weighing over eight ounces, and glass tumblers irrespective of weight, were made dutiable at $.10 a pound and objects weighing eight ounces or under at $.12. Furthermore, an additional duty of $.04 a pound was levied whenever the articles mentioned were equipped with stoppers or had ground bottoms. Finally, the duty on cut glass was made proportional to the degree of cutting performed and was $.25 or $.45 per pound; cut-glass lighting equipment, however, was taxed at the highest rate.

After the tariff of 1842 that of 1846 seems the quintessence of simplicity. Specific rates were completely abolished. Window

[10] Perfumes and fancy vials and bottles above 6 ounces, not above 16 ounces, $3.00 per gross.

[11] The individual duties per gross were as follows:

Above 8 ounces, not above one quart	$3.00
Above one quart	4.00

[12] The individual duties for each bottle were as follows:

Not above ½ gallon	$.15
Above ½ gallon, not above 3 gallons	.30
Above 3 gallons	.50

TABLE 8

AVERAGE IMPORT VALUES, DEMIJOHNS, VIALS, BOTTLES, WINDOW GLASS, 1825–1860

Year	Demijohns (each)	Vials (gross)	Bottles (gross)	Window Glass (sq. ft.)
1825	$.41	$1.53	$4.94	$.108
1826	.40	2.67	4.89	.089
1827	.39	2.33	5.05	.126
1828	.35	2.66	4.74	.130
1829	.33	2.90	4.72	.142
1830	.31	2.99	4.30	.129
1831	.31	3.13	4.58	.129
1832	.29	2.35	4.61	.129
1833	.28	4.66	4.56	.091
1834	.29	6.05	5.05	.099
1835	.30	3.85	4.92	.064
1836	.31	9.61	5.39	.069
1837	.30	6.17	5.56	.073
1838	.30	5.59	5.40	.088
1839	.29	5.86	5.10	.043
1840	.29	7.07	4.63	.023
1841	.30	8.77	5.15	.074
1842	.29	5.31	4.74	.037
1843	.30	3.52	4.64	.035
1844	.27	4.33	4.75	.050
1845	.30	3.88	4.48	.103
1846	.29	5.03	5.12	.133
1847	.33	1.79	4.80	.089
1848	.24	1.88	3.77	.057
1849	.23	.85	3.71	.037
1850	.21	1.08	3.96	.033
1851	.22	1.68	4.29	.038
1852	.23	2.78	3.40	.037
1853	.21	2.98	4.26	.032
1854	.22	4.48	5.73	.031
1855	.22	not reported	6.00	.029
1856	.22	..	5.04	.031
1857	.20	..	4.98	.032
1858	.21	..	3.89	.032
1859	.22	..	3.61	.034
1860	.23	..	4.11	.040

Data from *Commerce and Navigation*, 1825–1860. Differentiated value figures not reported before 1825.

glass became dutiable at 20 per cent ad valorem, cut glass at 40, and all other glass and glassware at 30 per cent. Revenue being redundant in 1857, the act of that year reduced these duties to 15, 30, and 24 per cent, respectively.[13]

Summary of Duties by Branches of Manufacture

The average specific duty on window glass in 1824 was $3.50, which was 24 per cent more than the $2.83 average of 1816. This continued in force until 1833 (with the exception of a moderate increase from 1828 to 1832 caused by the imposition during this period of a $5.00 instead of a $4.00 rate on sizes above 10 x 15 inches). On the basis of the average box-value of window-glass imports during approximately the same period (1825–1832) the average specific duty of $3.50 was equivalent to an ad valorem duty of approximately 30 per cent.[14] This, however, vastly understates the extent of protection which actually existed. The duties on sizes less than 10 x 14 were so heavy that only insignificant amounts of the smaller sizes were imported.[15] The average value of window glass imported is exaggerated by the higher value of the larger sizes and therefore the ad valorem equivalents of the specific duties on the smaller sizes must have been much above 30 per cent; precisely how much cannot be determined. In so far as English cylinder-glass prices of 1824–1832 were similar to those quoted in 1845, the ad valorem equivalents were as follows: on sizes not above 8 x 10 inches 193 per cent, not above 10 x 12 inches 131 per cent, not above 10 x 14 inches 133 per cent.[16] Even on the basis of the 1824 domestic prices for best quality 8 x 10, the specific duty was equivalent to 46 per cent ad valorem. In 1828 the specific duty on the same size was equal to 37 per cent of the eastern price for best quality, 46 per cent of the eastern price for second quality, and 75 per cent of the highest western price for unspecified quality. At the

[13] *Tariff Acts,* pp. 140, 156.

[14] See Table 8. This table supplies all the data used in computing the average import values mentioned above and in subsequent pages, and is derived from *Commerce and Navigation* for the years indicated.

[15] See *Commerce and Navigation,* 1824–1832.

[16] See Table 9.

same time the duty on the 10 x 12 size was 70 per cent of the highest western quotation for this size.[17]

Though these relationships do not permit any precise statement of the degree of tariff protection on window glass between 1824 and 1832, that it was very high is unquestionable. Certainly not less than 30 per cent, the duty appears to have been over 100 per cent for certain sizes. Were the exact average figure known, it is probable that it would fall at least between 50 and 100 per cent, for there is no evidence whatsoever that America in this period was producing window glass at less cost and lower prices than England.

From 1833 to 1842 the specific duty on window glass was readjusted downward and in 1842 the equivalent ad valorem rate had fallen to 20 per cent. The degree of protection provided by the tariff of 1842 is revealed in Table 9.

Both the tariff of 1846 and that of 1857 gave window glass less protection than any other branch of glassmaking. From 1846 to 1857 the duty was 20 per cent and after 1857, 15 per cent.

Like window glass, the three classes of common glassware subject to specific duties enjoyed heavy protection between 1824 and 1832. From 1824 to 1832 the average specific duty on black bottles amounted to about 50 per cent of the average import value for the period. Between 1833 and 1842 the specific duties of 1832 were progressively reduced to the equivalent of 20 per cent ad valorem. The protective tariff of 1842 imposed the heavy average specific rate of $3.50 a gross and since the average import value from 1842 to 1846 was $4.75, protection during that period may be estimated at 74 per cent. From 1846 to 1860 the ad valorem rate was first 30 and then 24 per cent.

On vials the average specific duty from 1824 to 1828 was $1.125 per gross, the average import value, $2.30, and protection approximately 49 per cent. During the next four years import values averaged $2.84, duties $1.50, and protection 53 per cent. The specific duties set by the act of 1832 increased the average specific duty to $2.44, but this rate was continuously reduced to the 20 per cent equivalent of 1842. Between 1842 and 1846

[17] See Chapter V.

tariff protection amounted to 54 per cent, for the average import value and the average specific duty for this period were $4.41 and $2.37 a gross, respectively. The ad valorem duties imposed by the acts of 1846 and 1857 were 30 and 24 per cent.

Tariff protection enjoyed by domestic producers of demijohns averaged 71 per cent from 1824 to 1832, declined to 20 per cent in 1842, remained at 110 per cent from 1842 to 1846, continued

TABLE 9

PRICES OF ENGLISH CROWN AND CYLINDER WINDOW GLASS, 1845

	Size in inches	Price per 100 sq. ft.	U.S. duty per 100 sq. ft.	Equivalent % ad valorem
Sheet or Cylinder Glass	4 x 6 to 6 x 8	$1.33	$2.00	150
	7 x 9 to 8 x 10	1.78	2.00	112
	9 x 11 to 10 x 12	2.67	2.50	94
	10 x 13 to 10 x 14	3.00	3.50	117
	10 x 15 to 11 x 16	3.56	4.00	112
	11 x 17 to 12 x 18	3.56	5.00	140
	12 x 18 to 16 x 24	4.00	6.00	150
	18 x 24 to 31 x 42	4.88	6.00	123
Crown Glass	4 x 6 to 6 x 8	1.78	3.50	197
	7 x 9 to 8 x 10	2.22	3.50	158
	9 x 10 to 10 x 12	3.56	5.00	140
	10 x 13 to 10 x 14	4.00	6.00	150
	10 x 15 to 11 x 16	4.66	7.00	150
	11 x 17 to 12 x 18	5.37	8.00	149
	12 x 19 to 18 x 26	6.66	10.00	150

Data from *Reports* of the Secretary of the Treasury of the United States, V, 322, 324. The table in the report carries the subscription "Wm. Chance, Jr , per James H. Hervey."

at 30 per cent for eleven years after 1846, and fell to 24 per cent in 1857. The specific duty was $.25 until 1833 and averaged $.32 under the tariff of 1842. Average import values were $.35 from 1825 to 1832 and $.29 from 1842 to 1846.

Since the quantity figures reported in *Commerce and Navigation of the United States* are not clearly and continuously applicable to the value totals, it is impossible to compute average

import values for glass and glassware imports other than those subject to specific duty. Because of this fact, no precise and but few approximate statements may be made concerning the extent of tariff protection enjoyed by the highly important demijohn branch of the glass industry. From 1824 to 1833 the duty was 20 per cent and $.02 a pound. The increase over the 1816 rate, effected by the addition of the specific duty, was doubtless suggested by the proportions of the English export bounty, described by several commentators as over $.02 a pound.[18] The ad valorem equivalent of the mixed ad valorem and specific duty of 1824 of course varied inversely to the value of the glass so taxed. The data available permit only a very rough estimate of the ad valorem equivalent of the specific portion of the combined duty, but it was probably not less than 20 per cent on the cheaper grade of glassware. In 1832 Bakewell, Page, and Bakewell, flint manufacturers of Pittsburgh, declared that a pure specific duty of $.04 a pound would not have constituted less protection than $.02 a pound plus 20 per cent ad valorem.[19] If so, it appears correct to conclude that the prevailing protection of the dual duty was not less than 40 per cent, for had the equivalent of the $.02 a pound specific duty been less than 20 per cent, a doubling of that rate would not have compensated for the loss of the ad valorem duty. This at once indicates that a specific duty of $.01 a pound was roughly equal to an ad valorem duty of 10 per cent. This deductive estimate is reinforced by a further piece of evidence. In *American State Papers: Finance,* Volume IV, appear computations of ad valorem equivalents of combined ad valorem and specific duties on glassware. The document is dated 1823; it states that a specific duty of $.06 a pound and 20 per cent ad valorem on common tumblers was approximately equal to 87 per cent ad valorem. On this basis, $.01 per pound specific would have been equal to 11 per cent ad valorem.[20] It therefore seems safe to conclude that until 1833 the average duty on "all other" glass and glassware was not much above

[18] *New York Tariff Convention,* p. 123; McLane, *Report on Manufactures,* I, 123; Jarves, 2nd ed., p. 83.

[19] McLane, *Report on Manufactures,* II, 525–527.

[20] *American State Papers: Finance* (1858), IV, 27.

and perhaps somewhat below 40 per cent, cheaper articles in every case being taxed at higher rates than the more expensive.

In common with all other duties, those on all glassware not specifically designated declined between 1833 and 1842 to the level in force in 1820. If the $.01 per pound specific duty was in 1842 still equivalent to 10 per cent ad valorem, the pure specific duties imposed by the act of 1842 were equal to 100 and 120 per cent. Though these figures seem high, it must be remembered that the equivalents of the specific duties on window glass were, in 1845, almost uniformly greater. In any event it is clear that the duties of this period were very heavy. From 1846 to 1860 the ad valorem duties on this class of glassware were 30 and 24 per cent.

Except from 1842 to 1846, plate-glass imports were charged at the duties required of all other glass and glassware. Since domestic production was not even attempted until after 1850 and remained insignificant until after 1860, the duties on plate glass throughout the period 1820–1860 were of importance only for the revenue they produced.

The Consequences of Tariff Protection

THE WINDOW-GLASS INDUSTRY

In 1820, by virtue of tariff protection, American manufacturers of window glass dominated the domestic market; in addition the tariff act of 1824 increased substantially the advantage enjoyed by these producers. So satisfactory were the consequences of the tariff duties levied during the years 1824–1832 that in 1828 the manufacturers themselves testified before the House Committee on Manufactures that they could derive no further benefit from tariff protection except for higher duties on a few large sizes of foreign window glass. Such difficulties as beset the industry in 1828 arose, they said, from severe "domestic competition," a condition, in the early nineteenth century at least, indicative of prospects of high profits.[21] Imports of window glass, already a minor factor in total consumption in 1820, became of even less significance after 1824 (see Appendix,

[21] *American State Papers: Finance* (1859), V, 778.

Table 3).[22] They declined steadily until 1830, reaching in that year a low of 200,000 square feet. In contrast, in the following year American window-glass production was estimated to be not less than 9,000,000 square feet.[23] In 1820 the value of domestic output had constituted 89 per cent of total consumption; by 1831 the percentage had risen to 94. Foreign glass surmounting the heavy tariff wall of this period was composed primarily of large sizes and fine qualities. The domestic industry consequently underwent particularly active expansion in production of the smaller sizes and less excellent grades of glass.

In the subsequent period of decreasing protection, 1833–1842, the quantity of window glass imported greatly increased. The number of square feet of window glass brought into the United States in 1832 was approximately one-half the quantity of 1833 and about one-fifth that of both 1835 and 1842. Though we have no statistics to prove it, domestic production must have been substantially reduced. With the tariff of 1842, the duties on window glass once more became heavy (but were less burdensome to the smaller sizes than from 1824 to 1832). Imports again declined quickly and to lower levels than the imports between 1824 and 1832. The unit value of imports remained high from 1824 to 1832, fell between 1832 and 1842, and rose from 1842 to 1846.[24] The larger proportion of high-value window glass imported in the first and third periods, and conversely, the increased amount of low value window glass imported especially in later years of the second period, explain these fluctuating trends in average import values.

Upon the passage of the 20 per cent tariff of 1846 imports of window glass mounted rapidly and remained at unprecedented heights between 1850 and 1860. The renewed influx of smaller and cheaper glass is reflected in the falling and sharply reduced unit values of the years 1847 to 1860. The statistical testimony of 1860 reveals the fate of the domestic industry under 20 and 15 per cent tariff protection. In 1831 American window-glass

[22] All data of imports drawn from *Commerce and Navigation,* 1821–1860. For the quantity and value of imports of window glass, 1821–1860, see Appendix, Table 3.

[23] *New York Tariff Convention,* p. 126.

[24] See Table 8.

production had been 94 per cent of consumption; in 1860 it was 65 per cent.

What of domestic and foreign costs and prices between 1820 and 1860? The evidence strongly suggests, if it does not prove, that throughout the entire period foreign — especially English — window-glass costs, and hence prices, were lower than those in the United States.[25] This, of course, is what one would assume a priori; for window-glass manufacture, like all other divisions of the glass industry save pressing, was an activity in which the United States would not be expected to possess a competitive advantage. The technical features of the industry, one branch excepted, then required that labor should constitute a very high percentage of total cost. Capital investment was small and the economies derived from cheap fuel were far from sufficient to offset the fact that the United States was a high-wage country. Not until long after 1860 were improvements introduced which overcame this handicap. Though the prices and comments contained in the McLane Report on Manufactures and the New York and the Philadelphia price quotations clearly testify to a declining trend in domestic prices after 1820, it is equally clear that in 1845, the mid-point of the period under consideration, American prices were still far above the English. The average Philadelphia price (see Table 6) for sizes between 8 x 10 and 12 x 18 in 1845 was $2.03 per box of 50 square feet and the average English cylinder price for the same sizes, $2.91 per box of 100 square feet.[26] It would thus appear that American prices at this time were about one and one-half times the English. If the New York window-glass quotations of 1844 (see Table 5) are employed, the ratios for both the high and the low figures are approximately two to one. Moreover, when the average of

[25] It is of course true that the high domestic prices might have meant high profits rather than high costs. But this could have been so only temporarily; continuous price differentials in the absence of monopolistic conditions definitely indicate unfavorable cost factors.

[26] The English prices for crown are not included intentionally. At this time practically all American window glass was made by the cylinder process. In 1842 Niles records a Congressional petition from a crown works at Wheeling which states that of the nine crown window-glass works that had begun operations at various times in the past, this works alone remained in existence. (*Niles' Weekly Register,* LXII, 140.)

English cylinder prices for all sizes is compared with the New York quotations, both resultant ratios are only slightly under two to one. Since neither New York nor Philadelphia prices are lower before 1845 it seems just to conclude that somewhat the same relationships held true throughout the previous twenty years.[27] Between 1847 and 1860, when a much larger proportion of total domestic window-glass consumption was satisfied by importation, the differential between American and foreign prices probably decreased, for both the New York and Philadelphia quotations, particularly the latter, indicate continued decline. The possibility of variation in quality, thickness, and size in the price quotations employed, and the rarity of price quotations themselves, prohibits more precise comparison of the course of foreign and domestic window-glass prices from 1820 to 1860.

During the period of heavy protection lasting from 1824 to 1833 (really to 1841 since only four-tenths of the excess of the specific duties over an equivalent of 20 per cent had been removed before December 31 of that year), there was no improvement in the method of window-glass production. In so far as production costs fell in this period, the causes lay in the increased supply and improved skill of workers, an extended specialization of labor, and greater purity of raw materials. It is notable that although the years after 1846 were characterized by much lower protection, it was in this period that the efficiency of American glasshouse structures and American glass furnaces came to surpass those of Europe.

From 1820 to 1860 the cost of protection to the American window-glass industry was paid by American consumers. Before 1846 this cost was high; though it was reduced subsequently, it is probable that it nevertheless remained substantial.

THE COMMON-GLASS INDUSTRY

From the data of *Commerce and Navigation of the United States* it is not possible to derive a complete statement of the

[27] There is no evidence to indicate that foreign, especially English, prices were higher in the twenty years before 1845. In any event it is highly improbable that the differences were sufficient to alter fundamentally the magnitude of the foreign and domestic price differentials.

importations of common glassware. Analysis of this class of imports must therefore be based upon the large and probably representative sample provided by the available statistics of imports of bottles, vials, and demijohns.

From 1824 to 1832 the ad valorem equivalent of the tariff on black bottles was about 50 per cent, on vials at first slightly below and later slightly above 50 per cent, and on demijohns about 70 per cent. What was the effect of this increased protection? The quantity of black bottles brought into the United States annually between 1824 and 1832 was actually greater than during the preceding four years. Imports of demijohns exhibited a similar trend except that they more uniformly maintained higher levels. Imports of vials also increased heavily from 1824 to 1827, but after 1828 they declined even more sharply than they had increased and reached levels close to complete exclusion.[28]

The declining protection of the years between 1833 and 1842 allowed the quantity of imported bottles and demijohns to rise to greater heights. Imports of vials, however, remained insignificant despite the periodic readjustment of the tariff. Protection of bottles and demijohns under the provisions of the tariff of 1842 was even heavier than from 1824 to 1832; protection of vials continued about the same. Bottle and demijohn imports declined noticeably between 1842 and 1846 and the quantity of vials brought into the United States remained very small. Under the 30 per cent tariff of 1846 bottle imports surpassed the levels of 1842–1846 but were somewhat lower than between 1832 and 1842. Demijohns, which had enjoyed heavier protection than bottles previous to 1846, were imported in unprecedented amounts. Imports of vials increased slightly between 1846 and 1854. Under the tariff of 1857 fewer bottles were brought from foreign producers but demijohn imports reached new heights. Vials were not reported separately after 1854.[29]

This analysis leads to a number of conclusions. The fact that importation of bottles and demijohns continued to be heavy despite tariff protection of 50 per cent in the one case and be-

[28] See *Commerce and Navigation* for the years indicated.
[29] See *Commerce and Navigation* for the years indicated.

tween 50 and 100 per cent in the other unquestionably indicates a persisting variation in domestic and foreign costs and prices. If the situation had been otherwise, such protection would have prohibited entry of foreign goods of these classes (omitting the possibility that the imports represented products of a totally different nature than those produced domestically, a contingency of which there is no evidence whatsoever). From this relationship of costs and prices it appears that American consumers, as in the case of window glass, paid at least a large part of the costs involved in the maintenance of domestic production of bottles and demijohns.[30]

Since the duties imposed by the tariff of 1828 all but prohibited imports of vials, it is in this case not clear that foreign costs and prices were below those of the United States producers. The comments of the Committee on Glass of the New York Tariff Convention, however, indicate that this was so: "Previous to the late tariff [1828], this establishment [Dyott's] . . . on a more extensive scale than any other of the kind in the United States . . . struggled hard for existence, against foreign competition, and was upon the point of being closed, — since its enactment, the importation of foreign glassware of this description is nearly suspended . . . It is believed that a reduction of the tariff would operate a destruction of this establishment." The Committee also reports that since the tariff of 1828 "prices have been reduced fully fifty per cent and the quality of the

[30] The only domestic prices of common glassware discovered pertain to demijohns and black bottles; western prices of these in 1845 were:

Black wines	large and small	$9.00 per gross
Black porter	1 quart	9.00 per gross
	1 pint	7.00 per gross
Covered demijohns	½ gallon	.44 each
	1 gallon	.62 each
	4 gallons	.83 each
	5–6 gallons	1.17 each

The average of these domestic prices for black bottles is $8.33⅓ a gross; the average demijohn price is $.76¾ each. The average import value for black bottles of a similar if not identical size range was $4.48 a gross and for demijohns, also of similar size range, was $.30 each. These price differences are great and despite the possibility of quality differences in favor of the imported articles lend strong support to the argument developed in the text. (*Niles' Weekly Register*, LXII, 196.)

ware is at least equal, if not superior, to the foreign manufacture." [31] The latter quotation is manifestly an overstatement of the decline of vial prices; Dyott's own data, which certainly would have reflected prices in the best light compatible with truth, indicate that the prices of 1832 were about 20 per cent below the prices ruling from 1824–1827.[32] If Dyott's quotations of vial prices (see Table 7) are reduced to an unweighted average and compared with the average import value of vials imported in the years corresponding to Dyott's latest quotations, American prices appear to be lower than foreign. The average values of vials not above eight ounces imported in 1830, 1831, and 1832 were $2.99, $3.13, and $2.35 a gross, respectively.[33] The Dyott average for vials of the same size is $2.19 a gross. The uncertainty of variables other than price prevent a categorical statement that American production of vials was less costly than the foreign. It is not known, for example, that the quality and type of foreign vials were identical; indeed the very nature of specific duties encouraged importation of a better and more valuable grade of the commodity. Furthermore, the fact that the act of 1828 made vials of larger capacity dutiable at substantially lower rates than those applicable to smaller containers strongly reinforced this tendency and thus led to an even greater inflation of average import values. Both the continuing low quantity of vial imports and these rough price comparisons make it appear, nevertheless, that American consumers of common glassware, at least in 1832, suffered less from the protection granted domestic producers of vials than from that given to manufacturers of black bottles and demijohns.[34]

[31] *New York Tariff Convention,* p. 124.

[32] See Table 7.

[33] In the first two averages the more expensive larger vials received greater weight than they do in the mean of Dyott's quotations; in the third, however, the converse is true.

[34] Demijohns were said to require greater skill on the part of the workmen than the blowing of bottles or vials up to 1860. The production of black bottles in the United States seems never to have been great, the cause of which I have so far been unable to discover. Their scarcity was complained of in the earliest years of American glassmaking. Only one works producing such glass existed in 1831, and in 1845 there was but one west of the Alleghenies and several in the East. (*New York Tariff Convention,* p. 124; *Niles' Weekly Register,* LXVII, 196.)

The increase of bottle and demijohn imports after the tariff of 1846 suggests that the divergence of domestic and foreign costs and prices indicated for the earlier years persisted. Imports of demijohns increased more heavily than bottles, an event to have been anticipated from the stronger protection previously accorded this class of common glassware. The circumstance that bottle imports after 1846 were somewhat less than before 1842 seems to imply that here the disparity between foreign and domestic costs and prices was decreasing.

The quantity of vials imported under the duties of the act of 1842 shows no appreciable change. This fact, as well as the slight increase from 1846 to 1854, is entirely compatible with the apparent foreign and domestic relationship of 1832.

In so far as bottles, demijohns, and vials constituted a representative sample of common glassware we may conclude that protection from 1824 to 1860 permitted domestic glasshouses to satisfy a larger portion of total consumption of common glassware than they would have been able to supply without protection; that throughout the period 1820–1860 domestic costs and prices were generally above the foreign, vial manufacture alone possibly excepted; and that at least a large part of the cost of protection was paid by American consumers through the media of prices above those which would have prevailed had no protection existed. We may conclude further that the cost of protection of domestic production of common glassware was probably lower than in the case of window glass; that the protection induced no improvement in the process of manufacture; and that the most important factor in lower domestic costs, increased efficiency of American glasshouse structure and furnaces, was initiated in the period of moderate, not the period of heavy, tariff protection.

THE FLINT-GLASS INDUSTRY

To analyze the effects of the tariff on the production and consumption of flint glass in the United States between 1820 and 1860 it is necessary to employ an import series which includes not only flint but other types of glassware as well. The data which form the basis of the analysis comprise flint, the portion

of common glassware not eliminated by the omission of black bottles, vials, and demijohns, and other glass and glassware such as plate (before 1843) and glass novelties. Though this circumstance further complicates an already difficult problem, it is believed that flint imports were a sufficiently forceful factor in the totals of the series to have determined the trends revealed.

From 1824 to 1842 tariff protection on flint glassware approximated 40 per cent on cheaper articles and probably less than 40 per cent on the finer articles. Between 1842 and 1846 protection was much greater, but the trend of imports was steadily upward.[35] The complexity of the items in the import series utilized, the variety of products included in the general classification of flint glassware, and the diversity of qualities forbid a categorical conclusion that this growth of imports in the face of more than moderate tariff protection reflected relatively higher domestic costs and prices. It is probable but not obvious that this was so.[36] This statement is supported by the testimony before the Committee on Manufactures in 1828. It reports that the prevailing tariff duties had had favorable consequences, that the flint manufacturers were then in a prosperous condition, and that no further protection was necessary. The Committee on Glass of the New York Tariff Convention reported in 1831 that "the American manufacturers are satisfied with the existing duty on imported flint-glass." It added that "a repeal of the duty on glass, even to the extent of the protection now afforded by the tariff, might not wholly stop the manufacture of it in this country — but a great influx of the foreign article would undoubtedly ensue." [37] Although both of these quotations declare that American flint prices had fallen, the verbal and statistical evidence necessary to an accurate appraisal of foreign and domestic costs and prices and, hence, the precise effect of protection on American consumers, is missing. It can only be said that it is probable

[35] For the value of "flint and other glassware" imported 1820–1860, see Appendix, Table 9.

[36] This argument is not supported by flint imports in 1831, for we know that at that time imports were a negligible part of total consumption. Imports and domestic production of flint in 1831 were estimated at $125,000 and $1,300,000, respectively. (*New York Tariff Convention*, pp. 123, 126.)

[37] *New York Tariff Convention*, p. 124.

that domestic consumers underwrote American production of flint glassware by payment of prices in some degree higher than the foreign.

Although the period 1846–1860 was one of moderated protection, it witnessed a great expansion of the flint-glass industry. Imports meanwhile increased, but not to levels proportionate to the growth of production. In 1831 domestic output of flint was $1,300,000; in 1860 domestic production of glass other than window and plate (largely flint) was $7,063,785. Three factors account for this development: improvement in glasshouses and furnaces; growth of the pressed glass industry; and abandonment of the English export bounty on flint glassware.

In the years before 1846 it is repeatedly mentioned that the English bounty reduced the tariff on flint to an equivalent of less than 20 per cent.[38] After 1846 this premium was no longer paid.[39] This fact, and the lower cost of glass-melting which followed improvement in American furnace construction, diminished the differential between domestic and foreign flint production costs and prices. Imports from 1846 to 1860 undoubtedly would have been greater than they were had not these events occurred.

But the fundamental cause of the relatively slow growth of flint imports after 1846, and of the great progress made by the American flint-glass industry from about 1840 to 1860, was the development of glass manufacture by pressing. In 1860 more than three-fourths of all flint glassware was pressed. Prices had been so reduced by this process that consumption had been multiplied tenfold; consequently more flint was produced in the United States than in England, the birthplace of the industry. By the introduction of mechanical processes this branch of the American glass industry had overcome the handicap of high wages and assumed a position of leadership based upon low cost and high quality of output.[40] Exports testify to this fact.[41] Although from the earliest years of the nineteenth

[38] *New York Tariff Convention,* p. 124; McLane, *Report on Manufactures,* I, 123; *Niles' Weekly Register,* XVI, 403.

[39] See Chapter IV.

[40] Jarves, 2nd ed., p. 88.

[41] For value of exports, 1826–1860, see Appendix, Table 2.

century a small amount of American glassware had been sent to foreign countries, primarily to South America, it was only in the period which witnessed development and expansion of the pressed-glass industry that exports rose above insignificance.[42] It is a matter of record, unofficial but apparently trustworthy, that a commanding portion of the domestic glassware exported was attributable to pressing.[43]

The preceding analyses lead to certain summary conclusions. From 1820 to 1860, in all branches of glassmaking except pressing and possibly vial manufacture, American costs of production and prices were higher than those of competing foreign countries. The tariff duties enforced during this period permitted expansion of high-cost domestic production on a scale which otherwise would have been impossible. The cost involved in this program was in a large part paid by domestic consumers. Moreover, the one important technical innovation which marked the history of American glassmaking from 1820 to 1860 occurred in a period of only moderate tariff protection, and apparently owed its origin to factors other than a policy of tariff protection.

[42] The New England Glass Company and the Boston and Sandwich were particularly important as American glassware exporters (Watkins, pp. 15–16).

[43] "Some Domestic Glass Lore," *National Glass Budget,* XVIII (December 27, 1902), 1; "An Interesting Glass Story," *National Glass Budget,* XXI (April 28, 1906), 1.

CHAPTER VII

GLASS MANUFACTURE, 1860–1890
THE RISE OF ORGANIZED LABOR

The Window-Glass Industry

EXPANSION

Between 1860 and 1890 the American window-glass industry underwent a new era of expansion comparable in magnitude to the growth characteristic of the period 1820–1831. In the decade 1860–1870 this as well as all other branches of the glass industry enjoyed a wave of activity closely approaching the proportions of a boom.[1] The Census of 1870 reported the value of domestic output of window glass at slightly under $4,000,000.[2] This represented an increase of about 170 per cent over the figure returned in 1860, and while it is undeniable that the 1870 figure was distorted by the price changes attending the Civil War, the reality of significant expansion is demonstrated by the fact that both the number of workers and the number of firms seem to have increased at an even greater rate.[3] In 1860 there were said to be 1416 glassworkers in thirteen factories and a decade later 2859 in thirty-five factories.[4]

Expansion of window-glass output and of production in the glass industry as a whole was accompanied by sharply rising prices, wages, and cost of materials. The extent of the upward movement of window-glass prices is not clear. One source states

[1] "Historical Data About Glass," *National Glass Budget*, XVII (August 10, 1901), 1.

[2] Department of the Interior, *Statistics of the Wealth and Industry of the United States Compiled from the Original Returns of the Ninth Census, June, 1870* (1872); hereafter cited as *Ninth Census*.

[3] *Eighth Census, Ninth Census.*

[4] The 1860 census figures appear surprisingly low, however, and may reflect incomplete reporting.

that during the war period they were very high. Another, however, reports quotations which indicate that the price of 8 x 10 inch glass in 1864 was not so much above the quotation of 1854 as 1864 prices of other glass products were above their 1854 quotations.[5] In 1867 blowers and flatteners in Pittsburgh were said to have been paid $250 a month; some indeed were reported to have received as much as $20 a day.[6]

Expansion of the window-glass industry continued from 1870 to 1880, but, largely because of the depressive trade conditions, at a much slower rate. Total production in 1880 was valued at $5,047,313.[7] This constituted an increase of 32 per cent. The rate of growth in quantity of output doubtless was greater than that indicated by the value relationships, for prices of window glass were falling throughout this period. Expansion was accelerated between 1880 and 1890. Quantity of output more than doubled (93,000,000 square feet in 1880 and 188,000,000 square feet in 1890) and value of output rose to $9,037,187, or by 78 per cent.[8] The difference in these last rates of quantity and value increases may be accounted for by falling prices. Window glass 8 x 10 inches, no quality specified, sold in 1874 for $2.30 a box and in 1888 for $1.80, a decrease of 22 per cent.[9] The upward trend of wages which characterized the period 1860–1873 terminated about the latter year; the trend

[5] "History of the Skilled Window Glass Workers' Trade," *Glassworker,* XXXV (August 11, 1917), 2; *National Glass Budget,* XIV (May 6, 1899), 1.

	1854	1864
Pressed goblets, per dz.	$2.33	$3.50
Pressed tumblers, per dz.	.66	1.30
Pressed wines, per dz.	1.25	1.73
Four-inch nappies, per dz.	.40	.72
Lamp chimneys, per dz.	1.75	2.25
Window glass, 8 x 10, per box	3.50	3.75

[6] Clark, p. 143, citing *Scientific American,* XVI (January 5, 1867), 3; *Glassworker,* August 11, 1917, p. 2.

[7] Department of the Interior, Census Office, *Report on the Manufactures of the United States at the Tenth Census* (1883); hereafter cited as *Tenth Census.*

[8] *Tenth Census;* Department of the Interior, Census Office, *Report on Manufacturing Industries in the United States at the Eleventh Census, 1890: Part III, Selected Industries* (1895), hereafter cited as *Eleventh Census;* "Growth of the Glass Industry," *National Glass Budget,* XV (December 30, 1899), 1.

[9] *National Glass Budget,* May 6, 1899, p. 1.

thereafter was reversed, continuing downward until the renewed activity of 1880–1881.[10] In 1882 window-glass blowers' wages in the East ranged from $60 to $100 per month and on an average were $80 to $85; western wages were higher.[11]

IMPROVEMENT OF PRODUCTION METHODS

Both the process and technique of window-glass production remained unchanged in the twenty years following 1860. Throughout this period, and the greater portion of the succeeding decade as well, the status of the industry with respect to production methods seems to have been inferior to that of European glassmaking nations.[12] Until 1873 production under existing technique was profitable and consequently there was no necessity for or premium upon improvement. From 1873 to 1879, however, the glass industry experienced trying times and strenuous efforts were made to reduce costs.[13] This circumstance seems to have been at least a contributing factor in the series of changes which were instituted immediately thereafter. In the early years of the decade 1880–1890 a succession of minor improvements in the technique of cylinder-blowing took place. About the same time several more fundamental changes were introduced in the annealing and flattening processes. A few years later the method of glass-melting was improved in two highly important respects. In almost every case, however, these developments represented adoption of methods and practices originating and previously utilized in other glass-producing countries. All improvements introduced into the American window-glass industry to 1890, indeed to 1900, therefore appear to have merely reduced an already existing industrial inferiority of the United States.[14]

[10] *National Glass Budget,* August 10, 1901, p. 1.

[11] U.S. Tariff Commission, *Report of the Tariff Commission, 1882* (1882), II, 2006.

[12] Clark, p. 499.

[13] *National Glass Budget,* August 10, 1901, p. 1.

[14] In several cases it is impossible to give the exact date of the introduction of improvements, but the general time range is in every instance clearly defined.

One of the most important of the adopted innovations in cylinder formation was the blow furnace, in the use of which English manufacturers had led the way. This auxiliary heating chamber aided the gatherer in "getting out" first and second glass and blocking it while the blower was swinging out, opening and finishing the previous cylinder. Blow furnaces were first employed in the United States sometime in the 1880's and became common between that time and 1900. About the same time a device known as the "lazy-bones" began to be used. The lazy-bones was an armed crotch placed over the blowing block to support the weight of the pipe and the "nabel" (the partly formed ball) during the process of forming the neck and shoulders of the cylinder, a task formerly performed off-hand. A third improvement was the abolition of the overhead foot bench, which occurred after the introduction of the blow furnace. The overhead foot bench, a raised working platform, wasted energy and time.[15]

Until the late 1870's the blocks used to "marver" or shape the preliminary form of the window-glass cylinder were made of wood. During the process of blowing and forming it was necessary to prevent the blocks from burning by feeding water to them; this was usually accomplished by means of a suspended tin cup with a hole punctured in it near the botton and opposite the handle. Shortly before or about 1880, an iron block was introduced, but considerable difficulty was experienced in obtaining a surface which would allow the ball to turn easily without scratching the glass. Charcoal, wooden facings, and sawdust were the important protecting agents utilized.[16]

Friction wheels on swinging cranes came into the American window-glass industry after the improvements already mentioned. These devices enabled the blower to swing out his "roller" repeatedly without the earlier necessity of raising the crotched pole under the pipe. The use of the wheels, together with the fact that the gatherer no longer had to climb to an

[15] "A Brief Sketch of the Window Glass Industry," *National Glass Budget,* XVIII (May 2, 1903), 3.

[16] *National Glass Budget,* May 2, 1903, p. 3.

overhead foot bench, permitted larger and heavier gathers and an increase in the size and weight of the cylinders blown.[17] A further minor improvement in the fashioning of the glass cylinder was brought about by the invention of the style of swinging out known as "pompadouring"; this came into vogue about 1885.[18]

It appears that no improvement in the annealing and melting of window glass occurred before 1880. When innovations did come, however, between 1880 and 1890, they proved to be of a more fundamental character than those affecting the actual fashioning of the cylinder, which were of minor significance and related to technique rather than process.[19] In spite of the significance of the melting and annealing innovations, their widespread adoption did not occur nor their full effect become apparent until the decade 1890–1900. The first consequential development was the introduction of the Tondeur and rod lehrs. The former appeared in 1881–82, the latter about 1884–85. A few years later it was estimated that there were 102 patented varieties infringing upon one another, a circumstance which left in its wake ten years of litigation.[20] Annealing previously had been done in kilns. These kilns, heated to proper temperatures, were filled with glass, sealed, and allowed to cool gradually over a period of days. The lehr, a mechanical device providing for gradual movement of sheets of flattened window glass through a tunnel-like annealing furnace, was not only a quicker but a more efficient method of annealing.[21]

Little was done to improve the process of glass-melting until after 1880. Rectangular pot furnaces were used in window-glass production during all but a few years of the period 1860–1890.[22] As before 1860 the size of the pots employed continued to be

[17] In 1880 the usual weight of the gather was about twenty pounds (Weeks, p. 50).

[18] *National Glass Budget,* May 2, 1903, p. 3.

[19] "Window Glass Making," *National Glass Budget,* XIII (June 5, 1897), 1.

[20] "History of Plants," *Glassworker,* XXXVI (July 27, 1918), 20.

[21] About this same time a four-stone flattening oven came into use. ("Phillips Selected Head of Window Glass Manufacturers," *Glassworker,* XLI [August 12, 1922], 13.)

[22] "Modern Factory Construction," *National Glass Budget,* XIX (May 30, 1903), 1.

increased; those used in 1881 were said to have a capacity three times the average capacity of pots in 1856. Although the first successful gas furnace for glass, the Siemens, had been perfected in 1861 and quickly utilized in many of the factories of England, France, Belgium and other European glassmaking countries, few had been built in the United States as late as 1890. Shortly before this time several American factories had installed Gill and Nicholson furnaces, both domestically developed forms of the gas furnace. The Nicholson furnace was an improved form of a French construction, differing from the Siemens in not having alternate regenerators. The Gill, on the other hand, was said to be an improvement on the Boetius principle that had been successfully utilized in Germany. It was claimed for the Gill that the original cost was less than for the Siemens, that it was more efficient and cheaper in operation than the ordinary furnace, and that it could be adapted to remodeled direct-firing furnaces.[23]

In general it may be said that gas furnaces were unimportant in the window-glass and other branches of the American glass industry until the discovery of natural gas, which was first used in window-glass manufacture in 1881–82.[24] This development wrought great changes and had a profound effect upon localization of the industry. By 1880 coal had become firmly established as the accepted glassmaking fuel; it was used by the remaining firms in the East as well as by those in the western area, despite the cost disadvantage entailed in transportation charges. Gas, however, was a well-nigh perfect medium for glass-melting, burning at intense heat, leaving no residue, and having no deleterious effect upon the batch.[25] Such advantages placed a heavy premium upon its adoption. Forthwith the American glass industry resumed its wandering habits.[26] The growing use of coal had ended the itinerant search for wood fuel, but

[23] Weeks, pp. 36–37.

[24] *Glassworker,* July 27, 1918, p. 20.

[25] "Pittsburgh and the Glass Industry," *American Glass Review,* XLVI (March 26, 1927), 15; "Glass and Machinery — Ancient and Modern," *National Glass Budget,* XLIII (October 16, 1926), 19.

[26] E. H. Bostock, "Notes on Sheet and Plate Glass Industry," *American Ceramic Journal,* 1920, p. 35.

TABLE 10

LOCATION AND REGIONAL DISTRIBUTION OF OUTPUT IN THE GLASS INDUSTRY, 1860–1890

	Number of Factories				Value of Output			
	1860	1870	1880	1890	1860	1870	1880	1890
Massachusetts	11	14	11	7	$ 2,004,000	$ 2,371,000	$ 854,000	$ 431,000
New Hampshire	2	2	1	0	32,000	63,000	70,000	...
Connecticut	2	3	1	0	58,000	48,000	160,000	...
New York	18	40	32	32	1,198,000	2,163,000	2,421,000	2,723,000
New Jersey	16	19	27	35	1,098,000	2,806,000	2,810,000	5,218,000
Maryland	0	2	8	11	. .	236,000	587,000	1,257,000
Pennsylvania	31	52	78	102	3,463,000	8,301,000	8,720,000	17,179,000
West Virginia	2	1	4	7	220,000	200,000	748,000	945,000
Ohio	4	9	20	67	91,000	619,000	1,549,000	5,649,000
Illinois	0	2	7	14	...	186,000	901,000	2,372,000
Indiana	0	3	4	21	...	789,000	791,000	2,995,000
Missouri	2	4	6	6	282,000	238,000	920,000	1,215,000
Kentucky	1	3	5	4	65,000	447,000	388,000	...
California	0	0	1	1	...	. .	140,000	...
Michigan	0	0	1	1	...	...	90,000	...
Iowa	0	0	3	0	...	...	3,000	...
All other states	0	0	2	9	...	...	. .	1,065,000
United States	89	154	211	317	8,512,000	18,467,000	21,154,000	41,051,000

Data from *Eighth Census, Ninth Census, Tenth Census, Eleventh Census*. The value totals do not always exactly equal the sum of the individual items because of "rounding off." In cases where factories are reported for states but no value output is indicated, they are either reported together to avoid revelation of confidential information, as in 1890, or not reported producing, as in 1880 and 1890 The table pertains to primary glass manufacturing only, secondary processing works are not included. In 1890 twenty-three factories were reported idle, and 294 in production.

the restrictive power of coal was broken by its successor, gas. The fact that the American glass factory was still typically a relatively small-scale, small-investment enterprise facilitated the process of migration and made it more rapid and spectacular. The magnitude and character of reorientation of location are clearly revealed in Table 10. As the gas supply of Pittsburgh dwindled, new glasshouses were built in the gas fields of Ohio and northwestern Pennsylvania. In 1870 Ohio had nine glass factories, in 1880 twenty, in 1884 thirty-two, and in 1890 sixty-seven. The natural pull of these new locations was accentuated by the eagerness of many communities for glassmaking establishments. Cities and towns not only offered temptingly low gas rates but free land and cash bonuses as well.[27] By 1886 communities in Indiana as well as Ohio were competing with one another on this basis. Indiana possessed but four glassworks in 1880; in 1890 the number had risen to twenty-one.[28]

The introduction of tank melting followed the adoption of natural gas.[29] Indeed it was impossible for it to have preceded the use of some form of gas, oil, or other "thrown-flame" fuel, for a direct-firing tank furnace was impracticable if not impossible. Tank furnaces, however, had been employed in Europe (with producer gas) several years before their introduction here, a circumstance which supplies another instance of the lagging technical development of the American glass industry in the nineteenth century.[30] The first tank for the manufacture of window glass, a day tank, was built in 1886–87.[31] The initial successful installation of the continuous tank in window-glass making was undertaken in 1888 at Jeannette, Pennsylvania, by

[27] *Glassworker*, July 27, 1918, p. 20; *Ninth Census; Tenth Census; Eleventh Census; Glassworker*, August 12, 1922, p. 13.

[28] *Tenth Census; Eleventh Census.* Window glass was first melted by gas in the furnace of the Bradford Window Glass Company in the Pittsburgh district ("Pittsburgh Stands High in Chemical Research Work," *National Glass Budget*, XXXVIII [November 11, 1922], 1).

[29] "The Window Glass Industry," *National Glass Budget*, XXXIV (September 7, 1918), 1.

[30] "Continuous Tank Furnaces," *National Glass Budget*, XXIV (January 22, 1909), 1. Tank furnaces came into common use in Belgian window-glass factories, for example, shortly after 1880.

[31] "Window Glass Progress in Last 20 Years," *Commoner and Glassworker*, XXIV (October 18, 1902), 7.

James A. Chambers, one of the most active American window-glass manufacturers. Despite the conspicuous success of the Jeannette experiment, tank furnaces in 1890 had won no general acceptance, had been built in only a few glasshouses, and were still looked upon with great suspicion. The tradition of more than a century of pot melting was not to be easily destroyed. Accordingly, the era of the tank furnace in the United States was delayed until the last decade of the nineteenth century.[32]

THE RISE OF ORGANIZED LABOR AND BILATERAL MONOPOLY

All that has been said so far, however, is subsidiary to the outstanding feature of the history of the American window-glass industry from 1860 to 1890, the birth and reign of "L. A. 300," one of the most powerful labor unions in the history of the United States.[33]

Before 1860 window-glass workers were either unorganized or organized in small and uninfluential local bodies. Little is known of them but it is clear that there was no regional or national association. The organization developments of the years of high prices and high wages subsequent to 1860 laid the ground for the *rapprochement* of 1879. In 1865 the blowers of Pittsburgh organized the Window Glass Blowers Union Number 1, and by 1867 there was also a gatherers' union at Pittsburgh.[34] Sometime later the cutters and flatteners of this city formed locals. Before 1879 glassworkers in the East were organized in mixed assemblies of the Knights of Labor. In the

[32] "Continuous Tank Furnaces," *National Glass Budget,* XXIV (January 22, 1909), 1.

[33] "Thirty-five Years in the Glass Industry," *American Glass Review,* XLV (April 3, 1926), 17.

[34] "History of Window Glass," *Glassworker,* XXXIV (October 30, 1915), 6. In 1830 the Pittsburgh district was then the western country in glass manufacture and the Monongahela River valley was an important element in the production of window glass. In the valley above and below Brownsville there were twelve window-glass works supplying window glass to western consumers. In 1830 the blowers of these plants signed an agreement not to take any apprentices for a five-year period. This is thought to have been the earliest organization of window-glass workers in the United States. ("The Window Glass Blower Passes," *American Glass Review,* LIV [September 7, 1935], 21.)

northern district (including New York, Massachusetts, and the northern part of Pennsylvania) the workers were partially organized in independent bodies.[35] The first attempt to form a union of the four trades was unsuccessful; Pioneer Lodge Number 1, Artsmans Association, projected at Ottawa, Illinois, in 1872, lasted only a short time.[36]

In 1877 or 1878 the gatherers' local at Pittsburgh joined the Knights of Labor as Local Assembly 300. Following this the cutters and flatteners, and later the blowers, took membership.[37] In explanation of the leadership assumed by the gatherers it should be pointed out that these workers were in a relatively unfavorable wage position. The blower for years had been considered the important factor in window-glass manufacture and consequently the gatherers received lower wages, lower than they considered just. After the Civil War they began to realize the importance of collective bargaining as an instrumentality for improvement of their position.

Shortly before August 18, 1879, the blowers and gatherers of Pittsburgh began a movement for consolidation of their interests. On that date the two local assemblies merged as L. A. 300, taking the gatherers' assembly number since it was the older and lower. So marked was the success of this consolidation that by February, 1880, the cutters and flatteners amalgamated with L. A. 300. Thereafter this national organization was known as Local Assembly 300, Knights of Labor, Window Glass Workers of America. Prospective members in other localities were urged to join and by 1881, it has been said, all window-glass workers in the United States were enrolled.[38]

The formation of the national union signalized the beginning of a rigid, detailed, and all-inclusive system of regulation of window-glass production that lasted into the early years of the twentieth century. This regulatory action had centuries of preccedent in the history of the glass industry; some supervision

[35] "The Window Workers and Their Organization," *Commoner and Glassworker,* XXIV (October 18, 1902), 25.
[36] *Glassworker,* October 30, 1915, p. 6.
[37] *Commoner and Glassworker,* October 18, 1902, p. 25.
[38] *Commoner and Glassworker,* October 18, 1902, p. 25.

and control had been attempted and achieved in the industry's earlier history in the United States.[39] Previous to the era of national unionization, however, there was little uniformity of wages, working rules, output, and apprenticeship regulations.[40] Frequently manufacturers made their own rules and wages, and relatively little benefit had been derived from such organization as had been achieved.[41] Before the national union was organized it was said that a Pittsburgh blower, for example, could earn as much with no gatherer to pay as the New York worker who had to pay the gatherer out of his wages.[42]

L. A. 300 set limits for the number of cylinders the workers were permitted to blow per hour and the number of boxes of glass made in any four-week period. Not more than thirty boxes of double-strength glass or forty-eight boxes of single-strength glass could be blown per month. For any excess the employing firm was required to pay the usual rate, not to the blower or gatherer but to the union. It was unwise for blowers to fulfill their production quota in less than the prescribed time, for the firm was then allowed to put other blowers in the formers' place to work out glass for which the regular blowers had to pay the union. The penalty for exceeding the limit applied alike to the man and the "pot," or working place. The hourly output limit was nine "rollers." There also were specific restrictions on the work of the cutters and flatteners. No flattener was allowed to flatten for more than four pots, and cutters could not cut for more than two and one-half pots making single-strength glass or for more than three pots making double strength.[43]

The union further regulated output by setting the length of "fire" or the yearly working period at ten months, from September 1 to June 30. Prior to 1879 there had been a summer vacation tradition in the industry but the "stops" or non-operating periods varied in length and sometimes occurred in the

[39] See Chapters I–V, *passim.*

[40] *Glassworker,* August 11, 1917, p. 2.

[41] *Commoner and Glassworker,* October 18, 1902, p. 25.

[42] *Glassworker,* August 11, 1917, p. 2.

[43] Department of Commerce and Labor, Commissioner of Labor, *Regulation and Restriction of Output,* 11th Special Report (1904), p. 607; hereafter cited as *Regulation and Restriction.*

winter when the blowers could work more easily, causing the plants to run through the summer when the work was difficult. Certain of the larger window-glass manufacturers protested the institution of the uniform "stop" rule but finally accepted it without forcing a strike. After 1885 the length of fire was reduced to nine months; considerably later it became the subject of a decision made annually at the time of the union-management wage-scale conference. Though regulation of the yearly working period was at its inception imposed partly as a means of production control, it was also intended to afford a uniform opportunity for making repairs and alterations. With the increase of productive capacity, the "shut-down" became more and more a device to reduce output.[44]

Restriction and regulation of the system of apprenticeship operated further to limit production but also constituted a vital factor in the maintenance of the power of L. A. 300. With few exceptions, only sons or brothers of legitimate workers were permitted to enter the four window-glass trades — blowing, gathering, flattening, and cutting. The term of apprenticeship in each of the four trades was three years. Application for admission to apprenticeship was submitted by a recognized workman, passed upon by examining boards, and finally by an executive board.[45] The executive board thus had complete control over the number of apprentices in training at any one time.

1879 was the first year of conference settlement of wages. For many years thereafter representatives of the manufacturers and the union met annually and determined the wage scale for the subsequent year. The ratio of payments among the four classes of workers was first settled at the time of amalgamation and changed thereafter only on a majority vote of the members of the other three trades. For each $1.00 received by the blowers, the gatherers received $.57 for single window glass and $.65 for double, the flatteners received $.27, and the cutters $.27 for single glass and $.42 for double.[46]

It is thus clear that from the beginning of its national history,

[44] *Regulation and Restriction,* pp. 600–601, 604.
[45] *Regulation and Restriction,* p. 617.
[46] *Regulation and Restriction,* p. 600.

L. A. 300 assumed rigid control of window-glass production. This control applied to the output of every window-glass worker and hence to the output of every window-glass factory. The only factor preventing complete regulation of national production as well as factory production lay in the possibility of building more factories. But even this escape was ineffectual as long as the union controlled the number of workers. The power of L. A. 300 was achieved quickly and with less resistance on the part of the manufacturers than one might have expected. Explanation of this is found in the essential craft nature of the industry, the supreme importance of the worker, a tradition of independence, intelligent leadership, and effective organization. Furthermore, it has been said that the manufacturers in 1879 were less opposed to control of production by labor than they would have been if the economic condition of the industry had been different. After 1860 productive capacity apparently expanded more rapidly than consumptive capacity, a condition greatly aggravated by the economic stress following 1873. Competition was severe and "as a solution of troubles occurring in 1877, the union undertook to unify conditions to the extent at least of fixing the running time of all plants alike, setting an equal amount of output per blower, and hence pot capacity, for each; and in addition to this it gave a differential to the localities where coal was most expensive, so as to even up conditions as much as possible." [47]

The same period which witnessed effective organization of the workers brought the first combination of manufacturers. The interests of the employers were represented by the American Window Glass Manufacturers Association. From 1880 to 1888 this association, with its Price List Committee, its Board of Control, its Districts, and its National Wage Committee was in full operation. It is said that the association decided how many and what works should be closed, what wages should be paid (in negotiation with the national union) and what prices charged.[48] The nucleus of the combination was the United Glass

[47] *Regulation and Restriction,* pp. 600–601.

[48] "The Window Glass Combines," *National Glass Budget,* XVII (May 25, 1901), 4.

Company, organized in 1880 and the owner of seventeen of the 108 plants then in existence.[49]

For more than twenty years after the inception of these organizations, the window-glass industry in the United States was ruled by the joint power of the combination of workers and the combination of employers. Wages for all window-glass workers were determined annually by a conference between representatives of the two monopolies. The union's system of limits and the complementary efforts of the manufacturers were directed toward close regulation of production and prices. The maunfacturers, however experienced difficulty in upholding their end of the program, especially with respect to control of prices, and consequently the history of the industry after 1880 is marked by recurrent periods of severe competition and price cutting.[50] Regulation of both production and prices, if not consistently maintained, was nevertheless the conscious goal in the industry up to and after the end of the nineteenth century. After excess capacity, the most powerful persuasive factor in attaining this goal was the extreme inelasticity of demand. The market for window glass was furnished almost exclusively by the building trades and the quantity purchased depended upon the amount of construction. Moreover, since window glass rarely exceeded 1 or 2 per cent of the total cost of any structure, even an extreme fluctuation in the price of so small a cost item had no appreciable effect upon the amount of building. A price concession of as much as 50 per cent brought no significant change in the amount sold. Retail dealers and local builders could not be tempted to lay in a stock of glass at low prices in anticipation of a rise because they did not know in advance how much or what sizes they would want. Finally, the building industry was highly speculative and therefore itself liable to extreme fluctuation.[51]

One minor and two major instances of industrial strife marked the history of collective bargaining in the window-glass industry from 1860 to 1890. The two major strikes apparently

[49] *National Glass Budget,* May 25, 1901, p. 4.
[50] *National Glass Budget,* May 25, 1901, p. 4.
[51] *Regulation and Restriction,* 599–600.

consolidated the power of the union, for afterward no important conflict occurred for many years. In 1867 the New York window-glass workers demanded an increase in wages and more advantageous working rules. The manufacturers refused and the men were dismissed. Primarily because of lack of aid from the Pittsburgh unions the strike was lost and a reduction of wages imposed. Thus armed with lower cost, the New York manufacturers were able to cut prices and compete effectively with the more advantageously situated western producers.[52]

The first major test of the strength of L. A. 300 came in the year 1882–83. The eastern workers contended for an advance in wages and a change in working rules. After protracted strife the workers emerged victorious; wages were raised to within a small percentage of those current in the western area. Following this, in 1883–84, occurred a struggle of the glassworkers of the western and northern districts against a wage reduction of 33 1/3 per cent. A conflict of over seven months was settled by the adoption of a sliding scale of wages based upon ruling prices, a settlement which represented no loss for the union if not complete victory.[53]

In 1884 and 1885 the large inflow of foreign workmen caused great concern to the officials of L. A. 300; the domestic labor supply was already sufficient for the glassworks then being operated. To forestall any undermining of the power of the union, L. A. 300 in 1885 called a meeting of representatives of the glassworkers of Belgium, England, France, Italy, and Germany.[54] The resulting convention organized the Universal Federation of Window Glass Workers of the World. Organizers were sent to the delegate countries and achieved appreciable success except in England. L. A. 300, however, withdrew from the Federation in 1890.[55]

[52] *Glassworker,* August 11, 1917, p. 2.

[53] *Commoner and Glassworker,* October 18, 1902, p. 25.

[54] *Commoner and Glassworker,* October 18, 1902, p. 25; *Regulation and Restriction,* p. 615. Neither the Germans nor the English attended, the former because of anti-union laws, the latter because of the weakness of their organization (a condition attributed to the open-apprentice system).

[55] *Regulation and Restriction,* p. 615.

TARIFF POLICY

Between 1860 and 1890 the American glass industry enjoyed a new era of heavy tariff protection. That the high duties of this period had their origin in the financial exigencies of the Civil War rather than in any conscious reversion to the policy prevailing before the tariff of 1846 did not diminish the effectiveness of their imposition and retention. The Morrill Act of 1861 anticipated later legislation; apparently for political reasons, it placed specific duties on window glass which, though lower than those of the preceding era of heavy protection, were nevertheless still relatively high.[56] The duties levied by the act of 1861 averaged \$.01875 per square foot on unpolished cylinder and common window glass and \$.0325 on polished and crown glass.[57] In 1864 the duties on both were revised upward and the comparable averages became \$.0225 per *pound* of unpolished glass and \$.145 per square foot of polished glass.[58] These duties remained in force until 1883 with the exception of the flat 10 per cent reduction operative between 1872 and 1875.[59]

The window-glass duties stipulated by the act of 1883 did not alter the rates of 1864 on polished glass. The new duties on unpolished window glass, however, averaged about 6 per cent

[56] Taussig, pp. 159–160, 192, 228.

[57] The individual duties per sq. ft. were as follows (*Tariff Acts*, p. 160):

	Cylinder and broad	Crown, polished, and all other
Not above 10 x 15	\$.01	\$.015
Above 10 x 15, not above 16 x 24	.015	.025
Above 16 x 24, not above 24 x 30	.02	.04
Above 24 x 30	.03	.05

[58] The individual duties were as follows (*Tariff Acts*, p. 230):

	Unpolished crown, cylinder, and common (per lb.)	Polished crown and cylinder (per sq. ft.)
Not above 10 x 15	\$.015	\$.025
Above 10 x 15, not above 16 x 24	.02	.04
Above 16 x 24, not above 24 x 30	.025	.06
Above 24 x 30	.03	..
Above 24 x 30, not above 24 x 60	.	.20
Above 24 x 60	..	.40

[59] *Tariff Acts*, p. 287.

less than the 1864 rates. From 1883 to 1890 the average specific duties on unpolished and polished window glass were $.02125 per pound and $.145 per square foot respectively.[60]

Unpolished window glass, i.e., window glass for glazing purposes, represented a very large proportion of total window-glass imports between 1860 and 1890.[61] Imports of polished crown and cylinder were almost negligible by comparison. Moreover, it appears that little if any polished crown and cylinder window glass was manufactured in the United States during this interval.[62] For these reasons, this type of window glass will not be considered in the following analysis.[63]

The ad valorem equivalent of the average specific duty on unpolished window glass in force from 1861 to 1864 amounted to 48 per cent and on the basis of the average applicable to the period 1865–1872 it amounted to 58 per cent. These data are computed from the average import values for the two periods, $.03925 per square foot for 1861–1864 and $.039 per pound for 1865–1872, and from the average specific duties of $.01875 per square foot and $.0225 per pound, respectively (see Table 11).

[60] The average of polished cylinder and crown is much distorted by the high duty on the largest sizes (*Tariff Acts,* p. 315). The individual duties were as follows:

	Unpolished cylinder, crown, and common (per lb.)	Polished cylinder and crown (per sq. ft.)
Not above 10 x 15	$.01375	$.025
Above 10 x 15, not above 16 x 24	.01875	.04
Above 16 x 24, not above 24 x 30	.02375	.06
Above 24 x 30	.02875	..
Above 24 x 30, not above 24 x 60	..	.20
Above 24 x 60	..	.40

[61] See Appendix, Table 3, and *Commerce and Navigation* for the years indicated.

[62] I have found no record of crown production in the United States during this period or of production of polished window glass. The processes employed in the production of polished window glass were allied to the processes of plate-glass production. But the plate-glass industry in the United States between 1860 and 1890 was fully occupied by the existing demand for polished plate. It is possible that this condition explains the apparent lack of polished window-glass production in this country before 1890.

[63] The ad valorem equivalents of the specific duties on polished window glass from 1860 to 1890 were lower than the equivalents on unpolished window glass.

War, imports of window glass declined sharply but rose thereafter and in 1873 reached levels higher than ever before.[66] After 1873, indeed after 1867, the course of imports reveals no distinct upward or downward trend; the fluctuations seem to follow the general economic activity of the nation. For the period as a whole, however, it is evident that increasing domestic production was followed by expanding imports. The lag of imports in both rate and amount of gain accounts for the somewhat better quantitative position of domestic production in 1890.

All the evidence indicates that at least for the latter half of the period 1860–1890, and almost certainly for the entire period, the status of the American window-glass industry with respect to processes and techniques was inferior to the window-glass industry of Europe. We should therefore expect to find American costs and prices higher than those of foreign competitors unless other factors interfere. The delayed adoption of gas fuel and continuous tank furnaces was in itself a partial cause of relatively high-cost glassmaking. No one of the series of improvements introduced into domestic window glassmaking about or after 1880, singly or collectively was of significance comparable to that of the tank furnace. Early utilization of this invention gave to European glassmakers an effective competitive weapon.

In addition to inferiority of technique and process, after 1860 (as before) American glassworkers' wages remained high both relatively and absolutely. Frank L. Bodine, testifying before the Tariff Commission of 1882, estimated that blowers' wages in the eastern glass-producing region of the United States were then a third higher than wages paid in Belgium, the most important window-glass exporting country.[67] The growth and power of L. A. 300 magnified or at least rigidified the wage discrepancy. The union further affected cost through its system of production control. Its limits on output were of less serious consequence in the early years of their imposition than later,

[66] See Appendix, Table 3.

[67] *Report of the Tariff Commission, 1882,* II, 2001. The discrepancy claimed in 1882 was much less than before 1860, when domestic wages were said to be two or three times the European.

for at the former time the limits approximated practicable maxima. With the coming of the tank furnace and other improvements, however, these rules prevented an increased worker productivity and thus removed a source of lower costs.[68]

If combination among workers directly and indirectly resulted in higher costs and prices, combination among their employers did also. In so far as price maintenance and price control were effective, a tempting inducement for over-capacity was created. It is probable that this condition existed by 1890 and certain that it did a decade later.[69]

From these several causes American window-glass costs and prices may be said to have remained well above those of chief competing countries from 1860 to 1890. This fact may be demonstrated in a number of ways. The simplest evidence is found in the continuing inflow of foreign window glass. In the face of a heavy tariff, imports rose rapidly from the early 1860's to a peak in 1873. After that time they fluctuated on a high level. This history of importation would have been impossible had not foreign prices been appreciably less than domestic.

More direct testimony is given by certain price data. In 1864 a box of fifty square feet of 8 x 10 inch American unpolished window glass was said to have sold for $3.75, in 1874 for $2.30, and in 1888 for $1.80.[70] On the basis of an estimate of fifty-three pounds per fifty square feet of glass, these prices were equal to $.071, $.043, and $.034 per pound.[71] Average import values per pound of window glass under 10 x 15 inches (and above 10 x 15 in 1864) for the same years were $.036, $.042, and $.021.[72] Except in 1874 the relative differences are substantial. Moreover, it is probable that the price divergences were actually greater than here indicated, since the import value figure for 1864 includes all sizes and those for 1874 and 1888 incorporate the effect of the more expensive sizes between 8 x 10 and 10 x 15. Another comparison may be made. The average

[68] *Regulation and Restriction,* pp. 601, 607–610.

[69] *Regulation and Restriction,* p. 600.

[70] *National Glass Budget,* May 6, 1899, p. 1.

[71] *Report of the Tariff Commission, 1882,* II, 2004. This estimate is the one used before the Tariff Commission of 1882.

[72] See *Commerce and Navigation,* 1864, 1874, 1888.

value of domestic window-glass production in 1888 translated into cents per pound was \$.045 and in 1890 it was \$.04.[73] The average value of unpolished window glass imported from 1865 to 1890 was \$.034 per pound; in 1880 it was \$.032 and in 1890 was \$.02 (see Table 11). In 1880, on the basis of the average import value for the entire period, American prices were 32 per cent above the average import value and in 1890 were 18 per cent above the average. If the average import values for 1880 and 1890 are employed the disparities are greater, being 41 and 100 per cent respectively.

The foregoing analysis of the economic development of the American window-glass industry from 1860 to 1890 leads to three general conclusions. First, it is clear that the renewed policy of heavy protection to the window-glass industry was productive of no acceleration of technical progress. Indeed, the effect seems to have been the reverse of progress. Until 1880 there was no improvement whatsoever in the process of manufacture. Meanwhile foreign glass countries were experimenting with if not utilizing methods virtually unknown in the United States. Furthermore, the improvements undertaken in the decade 1880–1890 were without major exception changes initiated and developed by foreign glass manufacturers. There is no better indication of the technical backwardness of the American window-glass industry in the thirty years following the Civil War than the fact that not a single continuous tank was used in the manufacture of window glass until a year or two before 1890. The tariff not only failed to stimulate technical advance but seems to have retarded it.

Secondly, it is apparent that heavy protection was a factor of primary importance in the development of bilateral monopoly in the industry. The control of prices and production achieved and exercised by L. A. 300 and by the association of manufac-

[73] The estimate employed here is sixty pounds to a fifty-foot box, the average for single- and double-strength glass used before the Tariff Commission of 1882. This probably reduces the average domestic values below what they should be because it is likely that less than half of the glass made in the United States at these dates was of double strength. (*Report of the Tariff Commission, 1882,* II, 2004.)

turers would have been impossible had protection been absent. The union would have had no power to set maximum hourly, monthly, and yearly output had foreign window glass been less heavily handicapped. Likewise, control of output, of plants in operation, and of prices would have been dependent upon factors other than the decisions of an association of manufacturers had a protective tariff been non-existent.

Finally, it is evident that the cost of tariff protection to the window-glass industry from 1860 to 1890 was in a large part paid by American consumers. Domestic costs and prices were higher than foreign costs and prices. The fact that American prices moved downward in the two decades after 1870 merely constituted a partial offset to the burden borne by the domestic market. In the thirty years following 1860 protection of the American window-glass industry can be credited with but one significant consequence — the maintenance of a quantitatively important domestic industry.

The Common-Glass Industry

imports and production

Analysis of the consequence of the tariffs imposed upon the importation of common and flint glass and glassware between 1860 and 1890 is rendered difficult by the dullness of certain necessary statistical tools. The Census of Manufactures, for example, does not report separate totals for domestic production of common and flint glassware until 1890 and therefore does not permit differentiation of the rates of growth in these two branches of the American glass industry before and up to that time. Furthermore the system of import classification employed by *Commerce and Navigation* prohibits the derivation of import series precisely comparable to the totals of domestic production and also prevents computation of complete import value figures. Finally, the multiplicity of products included in the common, or "green," and flint glassware categories, particularly in the latter, complicates cost and price comparisons and compels frequent resort to general rather than specific testimony.

Domestic production of glass and glassware other than win-

dow and plate in 1860 amounted to $7,063,785 and ten years later to $14,300,949.[74] These two totals constituted respectively 88 and 92 per cent of the total consumption.[75] In 1880 production of green glassware alone was $5,670,433 and in 1890 it was $8,521,464.[76] As reported in the census tables, green glassware comprised primarily, if not exclusively, green and black bottles, beer bottles, fruit jars, demijohns, carboys, and vials.[77] Unfortunately there is no way to determine the precise amount of green glassware imported. Since there is no exact statement, import totals have been constructed from the import value figures for "bottles and other containers." [78] This series has two defects when used in comparison with domestic production of green glassware. In the first place it omits for most of the years importation of bottles containing liquors, which were recorded by number and not by value. That such imports were of importance is apparent from their magnitude; in 1880 the number was over 4,000,000 and in 1890 over 9,000,000.[79] On the basis of the 1860 average value of imported bottles, $4.11 per gross, the value of these quantities approximated $122,000 and $259,000, respectively. A second defect errs on the side of overstatement rather than understatement. All bottles imported were not of green glass; some were of flint or lime. That portion of the total attributable to non-green glassware should be eliminated. Since this cannot be done, it has seemed prudent to disregard both the exaggerating and understating factors and to employ the data as they stand.[80]

[74] *Eighth Census; Ninth Census.*

[75] Flint and common imports: 1860, $980,000; 1870, $1,160,000.

[76] *Tenth Census; Eleventh Census.*

[77] Weeks, p. 11.

[78] See Appendix, Table 7.

[79] *Commerce and Navigation,* 1880, 1890.

[80] In 1890, when green and colored bottles, demijohns, and carboys were differentiated from other types for the first time, the total of the former was $779,844 and for all kinds $829,668, indicating that a very large part of the imports reported for bottles and containers were made up of imports of green-bottle glassware. This relationship also suggests that the omission of the value of bottles paying specific duties more than offset the inclusion of non-green bottles. Total imports of bottles and other containers are therefore probably slightly understated. (*Commerce and Navigation,* 1890.)

In 1880 domestic production of green glassware was 96 per cent of total consumption and in 1890 was 90 per cent.[81] Before the Tariff Commission of 1882 domestic production of green glassware was estimated at $7,000,000 and imports at $1,000,000. Even in this appraisal, which may have been colored by protectionist bias in so far as the import figure is concerned, domestic production was revealed as the predominant factor in the domestic market to the extent of about 87 per cent. The testimony before the Tariff Commission of 1882 also supplies some insight into the growth of the green-glass industry between 1860 and 1882, a period of years for which the census data are not helpful. The number of furnaces devoted to this type of production were said to have increased from sixty-four in 1860 to 108 in 1882, and the capacity of furnaces to have more than doubled in the same period.[82] The census value totals given above point to an increase in value of output between 1880 and 1890 of 50 per cent. Another source reports that productive capacity rose by 34 per cent in this decade.[83]

We may therefore conclude at this point that the years intervening between 1860 and 1890 constituted a period of substantial expansion in the green-glass branch of the American glass industry and that by 1880, and probably before, imports had become a minor factor in total domestic consumption.

IMPROVEMENT OF PRODUCTION METHODS

The methods of bottle manufacture current in 1860 and 1890 were distinguishable from one another in only two important respects, the degree of elaboration of the division of labor and the process of glass-melting. The actual forming technology remained unchanged; in 1890 as in 1860 bottlemaking was an art demanding high skill and complex manipulative technique.

In the decade 1880–1890 American bottle works, like the window-glass factories, slowly and cautiously began experimen-

[81] Imports of bottles and other containers: 1880, $240,000; 1890, $940,000.

[82] *Report of the Tariff Commission, 1882,* II, 2509. It is probable that a large part of this increase came before or by 1870; the years of the following decade were generally depressive. (*National Glass Budget,* August 10, 1901, p. 1.)

[83] *National Glass Budget,* December 30, 1899, p. 1.

tation with gas furnaces and continuous tanks.[84] Though the first continuous tank built in the United States, at Poughkeepsie, New York, in 1879, was for the manufacture of bottles, again as in the case of window glass, relatively little had been accomplished by 1890 with regard to tank construction.[85] The innovation that in the following decade was to bring substantially increased worker productivity encountered prejudice and opposition sufficient to delay full realization of its potentialities.[86] The transition in fuel, from coal to gas, buttressed as it was by valuable concessions from the newly discovered gas field areas, met with much less resistance.[87]

Improvement in American bottlemaking in the period 1860–1890 therefore resolves itself into the achievements arising from greater specialization of labor. For a great many years, the blowing of bottles by hand had been performed by a group of workers known as a "shop." Before 1870, however, the shop had consisted of a single blower and two boy assistants, a "mold" boy and a "snapping-up" boy.[88] After 1870, for the blowing of an average-sized bottle, the normal shop was made up of three skilled workers and four helpers. Two of the three skilled workers engaged in gathering and blowing independently of one another while the third worker finished the necks of the bottles made by his two fellows. In many if not all cases the three workers were equally skilled in gathering, blowing, and finishing and interchanged occupations every twenty minutes. The blowers' assistants derived their names from the nature of their tasks. The "mold" boy sat on a low stool at the foot of the blowers' bench and opened and closed the molds as required by the operations of the two blowers. The "cleaning-off" or "knocking-off" boy stood nearby and with a small iron tool resembling

[84] Before the coming of the tank furnace, the melting capacity of American bottle furnaces had been doubled; pots had been enlarged and furnace dimensions increased (*Report of the Tariff Commission, 1882,* II, 2509).

[85] *Glassworker,* July 27, 1918, p. 20.

[86] New Jersey Bureau of Statistics of Labor and Industries, *Twenty-Eighth Annual Report* (1905), p. 200; hereafter cited as *New Jersey Twenty-Eighth Annual Report.*

[87] *Glassworker,* July 27, 1918, p. 20.

[88] *New Jersey Twenty-Eighth Annual Report,* p. 201.

a file cleaned the blowpipe after it had been disconnected from the blown but unfinished bottle. The "snapping-up" boy put the unfinished bottle in a holding device known as a "snap" and placed it in the "glory hole"; the "carrying-in" boy carried the completed bottle from the finisher to the lehr for annealing.[89]

After the adoption of the seven-man shop, the average output per blower continuously increased. In the 1860's the product of good workmen averaged from forty to forty-two dozen bottles of eight-ounce capacity per day. By 1905 the average output of the larger shop had become three hundred dozen per day, or 138 per cent more for each individual blower than previous to 1870 under the single-blower system.[90]

A further minor though not unimportant improvement in bottle manufacture was effected by the introduction, in 1866, of chilled iron forming-molds. The significance of this change arose from the fact that their use made unnecessary the secondary finishing process formerly required by the defects of the ordinary rough-surfaced iron molds. The elimination of the final finishing step reduced the cost of manufacture.[91]

THE RISE OF ORGANIZED LABOR

Like the window-glass workers, the green-glass bottle blowers of the United States trace the genesis of effective labor organization from the years of the Civil War period. There are other similarities between the labor histories of these two branches of the American glass industry: both found their fundamental source of power in regulation of the supply of labor, both were able to make such control effective because of the nature of their craft, both worked for and established (the green-glass workers later than the window-glass workers) a system of collective bargaining and negotiation. Indeed the two labor organizations differed in but one fundamental respect: the green-glass blowers

[89] Department of Labor, Bureau of Labor Statistics, *Productivity of Labor in the Glass Industry,* Bulletin No. 441 (1927), p. 28; hereafter cited as *Productivity of Labor.*

[90] *New Jersey Twenty-Eighth Annual Report,* p. 201.

[91] "Progress in Mould-Making," *National Glass Budget,* XXIX (June 7, 1913), 11.

did not practice restriction of output as an integral part of union policy.[92]

The glass-bottle blowers were first organized in separate and independent eastern and western leagues of Green Glass Bottle Blowers. As early as 1842 a glass-blowers convention was held at Philadelphia and there are traditions of pre-Civil War struggles between employers and employees. Nevertheless, no effective organization was achieved until 1856 when a second convention was held at Philadelphia.[93] This convention expressed growing dissatisfaction with the company store system and the new practice of blowers' hiring mold assistants at half the "legitimate" journeymen's wages. The latter practice was denounced as being a violation of the established apprentice system. A constitution was adopted which had as its object the "elevation of position and maintenance of the interests of the craft," and the employment of molders at low wages was prohibited. Immediately thereafter local unions were established in eight cities in New Jersey, Maryland, and Pennsylvania. In July, 1857, a "Grand Union" was formed at a third Philadelphia convention of delegates from these local organizations. The Grand Union was given power to regulate the price lists (wage scales) of subordinate locals, to alter and amend local constitutions, and to decide all questions of appeal. The convention of 1858 limited the length of blast to nine months and forbade its members to work in plants where more than one indentured apprentice was employed, where low wage molders were employed, or where journeymen were paid less than the union scale of wages. It is said that these demands were made because of the attempts the manufacturers were then making to free themselves from the existing customary rules and regulations. An endeavor to make the demands effective induced a strike which was broken by the use

[92] *Regulation and Restriction,* p. 625.

[93] G. E. Barnett, *Chapters on Machinery and Labor* (1926), p. 72; "Sketch History of Glass Bottle Blowers Association," *Commoner and Glassworker,* XXII (July 13, 1901), 3. The subsequent history of the green-glass blowers' union is taken almost entirely from the latter source.

The earliest known union scale of prices for the blowing of bottles is attributed to the Western Glass Bottle Blowers, "assembled in mass convention in Pittsburgh," June 22, 1846 (*History of Wages in the United States,* p. 488).

of apprentices, nonunion journeymen, and workers from other states. The Grand Union thereupon collapsed and no successful reorganization occurred until after the Civil War.[94]

In 1865 a strike against an effort of the employers to reduce wages by 25 per cent was won by the workers. Partially as a result of this struggle the workers formed a new organization known as the Druggistsware Glass Blowers' League; in order to establish a new national league a convention was called at Philadelphia in 1866. It adopted what was virtually the constitution of the old Grand Union. A year later the first convention of the Western Division was held. In 1871 the league was reorganized and renamed the Improved Druggistware Glass Blowers' League of the United States. Locals were established and, it is reported, in a very short time most members of the craft east of Pittsburgh were included in its membership; in 1872 the western blowers organized an affiliated Western Division. Termination of strikes in 1883 and in 1885 brought victory for the workers.

In 1886 both the Western and Eastern Divisions affiliated with the Knights of Labor. In that same year, however, most of the New Jersey blowers and some of the New York and Pennsylvania blowers severed their connection with the League and formed the Glassblowers' League. In 1886 the Eastern Division had passed a resolution forbidding the taking of apprentices in 1886 and 1887 but the employers objected so strenuously that it was necessary to compromise on limited apprentices and reduced wages. Dissatisfied members of the league thereupon broke away. This fratricidal strife lasted until 1887 when the Glassblowers' League was reinstated by the Eastern Division. In that year also, reaffirmation of the limitation of apprentices (which supposedly had been in effect in both the Eastern and Western Divisions) precipitated one of the most bitter struggles in the history of the trade. The resulting lockouts in certain cases lasted for a period of years, but the union was eventually victorious.

In 1890 the two divisions merged into one national associa-

[94] A convention called in 1864 adopted a price list which with a few modifications was used for many years thereafter.

tion and the next year this body withdrew from the Knights of Labor to become the Green Glass Bottle Blowers' Association of the United States and Canada.

The workers in the green-glass branch of the American glass industry realized at an early date that control of labor supply through regulation of apprenticeship was fundamental to wage maintenance. Indeed the first unions in the East were destroyed by ineffective determination of this factor.[95] Accordingly the Green Glass Bottle Blowers' Association and all of its predecessors waged a continuous struggle to attain such control but only after 1889 did the limitation of one apprentice to every fifteen journeymen become effective.[96]

Like the members of L. A. 300, the green-glass blowers made strong and continuous efforts to dictate the length of the yearly working period. There was strong agitation for a nine-month blast from 1856 to 1857, but the resolutions adopted apparently were ineffective. From 1867 to 1870, however, a summer stop for the months of July and August was generally observed, the regulation being repealed by the union in the latter year. In 1880 the manufacturers and men agreed to cessation of work during these months, a practice followed for many years afterward.[97]

The Green Glass Bottle Blowers' Association and earlier unions also attempted to exercise supervision over working rules and working conditions. It appears, however, that nothing of great consequence was achieved before the formation of the national body in 1890.[98] After 1890, the union found itself able to maintain effective jurisdiction over such matters. Superficially it appears that L. A. 300 and the green-glass blowers were alike in this respect, but quite the opposite is true. The working rules prescribed and enforced by L. A. 300 were directed to limitation of output; those dictated by the Green Glass Bottle Blowers had other objectives. Though it is true that the summer stop was in fact a limitation upon yearly production, its institution arose from motives other than control of production.

[95] *Regulation and Restriction,* p. 639.
[96] *Commoner and Glassworker,* July 13, 1901, p. 3.
[97] *Commoner and Glassworker,* July 13, 1901, p. 3.
[98] *Regulation and Restriction,* p. 637.

Until about 1860 there was a "move system" in the flint glass bottle factories of the United States. This term signifies the number of pieces or dozens of pieces to be made at a turn, the turn being usually a half day . . . Day wages prevailed and the workmen had a specific compensation for a fixed number of bottles . . . Shortly after 1860 (the exact time cannot be given, and it probably did not occur simultaneously in the different localities) the making of bottles was put upon a strictly piece-price basis, and the limit to the day's work was abolished.[99]

It is not clear whether the text from which these sentences were taken was intended to apply to both flint and green bottlemaking, but the context indicates that it was. Whichever may have been the case:

The [Green] Glass Bottle Blowers and the prescription branch of the Flint Glass Workers are alike, in that there has never been in recent years [written in 1904] with two or three temporary exceptions, any "move list" or limitation of output. The exceptions in the green glass bottle industry were, one on Mason jars, . . . and the other an attempt made in 1887 to curb the pace setter in all lines of work by fixing a limit of $7 to the daily earnings of members. This latter limitation lasted but one year. It seems to have been set so high as to have had an effect the opposite from that intended; as the president of the association said: "The result was every man was breaking his neck to make $7 a day."[100]

The central goal upon which all the above regulations converged was maximization and maintenance of wages. For thirty-five years the union struggled to persuade employers to meet with them for the purpose of agreeing on wage scales. A national wage scale had been adopted at an early date but the record of annual conferences does not begin until 1886. Thereafter, however, wages, length of blast, and other matters were settled by the conference method; some time after 1890 the annual conference system gave way to biennial meetings.[101]

[99] *Regulation and Restriction,* p. 632.
[100] *Regulation and Restriction,* p. 625.
[101] Department of Commerce, Bureau of Foreign and Domestic Commerce, *The Glass Industry* (1917), p. 303; hereafter cited as *The Glass Industry, 1917.*

In the green-glass industry, therefore, as in the window-glass industry, the post-Civil War period witnessed the growth of a strong and eventually effective combination of workers. The organization in the green-glass industry, however, contrasts with L. A. 300 in slower growth of power, and in absence of restriction upon production. On the side of the manufacturers, the green-glass industry offers contrast also in the absence of employers' combinations comparable to those active in the window-glass industry before 1890.

TARIFF POLICY

The import duties on green glassware were rapidly increased by the tariff acts of 1861, 1862, and 1864. Under the act of 1857 common or green glassware had been dutiable at 24 per cent. Under the act of 1861 all plain mold or pressed glassware not cut, engraved, or painted was made dutiable at 25 per cent; under the act of the following year, at 30 per cent; and after the tariff of 1864, at 35 per cent. According to the same three tariff acts all filled bottles and jars were dutiable at 30, 35, and 40 per cent. In addition the act of 1864 imposed a specific tax of $.02 per container on imported bottles containing liquor, a rate which was increased by an act of 1870 to $.03 per bottle on containers of both liquor and wine. These duties remained unchanged until 1883 except for the flat 10 per cent reduction operative from 1872 to 1875. The act of 1883 provided a more elaborate schedule and had frequent recourse to specific duties. All green and colored bottles and jars formerly taxed at 35 per cent henceforth were charged at $.01 per pound, and if filled 30 per cent in addition. Flint and lime glass bottles were taxed at 40 per cent. Glass bottles and jars not falling within these two categories paid the duty applicable to unfilled bottles. Bottles containing liquors continued at the $.03 rate.[102]

The ad valorem tariff on bottle imports therefore ranged from 35 to 40 per cent between 1864 and 1872, from 31½ to 36 per cent between 1872 and 1875, from 35 to 40 per cent between 1875 and 1883, and from 30 to 40 per cent between 1883 and 1890. Bottles containing liquors imported between 1864 and

[102] *Tariff Acts*, pp. 160, 205, 230, 264, 287, 315.

1890 paid specific duties probably equivalent to not more than 50 and not less than 35 per cent ad valorem.[103] The specific bottle duties of the act of 1883, according to the equivalents reported by *Commerce and Navigation* from 1884 to 1890, averaged about 50 per cent for imports of empty bottles and somewhat less than 40 per cent for other bottles. Over the entire period bottles containing alcoholic beverages appear to have paid somewhat under 50 per cent and other bottles between 35 and 40 per cent.

Between 1860 and 1890 the American green-glass industry underwent steady expansion. By 1882 the number and capacity of green-glass bottle houses had about doubled. From 1880 to 1890 bottle-plant capacity increased by another 34 per cent. In this as well as earlier periods, however, the green-glass branch of the American glass industry remained one in which the United States could not have been expected to demonstrate a competitive advantage. In 1890, as in 1820, skilled labor was the predominant factor in green-glass production and hence wages were by far the major factor in costs. Frank L. Bodine stated before the Tariff Commission of 1882 that 90 per cent of the total cost of this class of glass products was attributable to labor.[104] Furthermore, glass blowers' wages, already high in 1860, fluctuated on a level higher than ever before during the following thirty years.[105] This competitive handicap was overcome and expansion of the domestic green-glass industry made possible through the instrumentality of the tariff. It was contended before the Tariff Commission of 1882 that so little change had been made in the tariff on bottles because "the industry was not until recently well organized, and as a result seldom urged its necessity at the time of fresh tariff enactments." [106] A further

[103] The average import value of bottles paying specific duties 1867–1869 (the only years before 1870 for which such computations may be made) was $.042 per bottle and the equivalent of the $.02 duty would have been slightly under 50 per cent. The value and duty-paid data for this same class of imports reported at the hearings of the Tariff Commission of 1882 indicate an ad valorem equivalent of 35 per cent. (*Report of the Tariff Commission, 1882,* II, 2511.) Ad valorem equivalents cannot be computed for the years 1870–1890.

[104] *Report,* II, 2509.

[105] *History of Wages in the United States,* p. 233.

[106] *Report,* II, 2510.

and perhaps more pertinent explanation may have been the adequacy of the tariff, for in 1882 when the necessity of greater protection was urged, the domestic market was already dominated by American producers. It is probable that the intensified competition claimed before the Tariff Commission in 1882 arose either from fruition of the technical progress of foreign bottle-making countries or from reduction of the incidental protection afforded by transportation costs, or from both. The packing and casing necessary to the transportation of such bulky and fragile objects as bottles had always afforded a considerable advantage to the home producer. By 1880, however, foreign bottles were being shipped in bulk (piled in bins), transferred in carload lots without packing, and carried at very low rates on the return voyages of grain and cotton freighters.[107]

During the period 1860–1890 in the American green-glass industry as in the window-glass industry, the effect of tariff protection upon production technology appears to have been neutral if not actually negative. Though it is true that the introduction of elaborated division of labor induced greater productivity, lower cost, and hence a competitive position more favorable than otherwise would have obtained, the fact that this amount of technical progress precipitated what might be called its "natural" consequence was attributable not to the beneficence of the tariff but rather to fortuitous circumstances. Had the Green Glass Bottle Blowers' Association been led or been able to effect a full system of output control, the tariff might well have caused invariable instead of increasing productivity. Protection of the green-glass industry from 1860 to 1890 had no obviously beneficial consequences unless domestic production in itself be so considered.

The Flint and Lime Glass Industry

EXPANSION OF OUTPUT

After 1860 the branch of American glass manufacture formerly designated the flint-glass industry could no longer be accurately described by such a simple term. True, lead glass

[107] *Report of the Tariff Commission, 1882,* II, 2510.

continued to come from American glass furnaces during the period 1860–1890. But its quantitative importance, great before 1860, constantly diminished; glass shapes formerly fashioned from flint metal were made with increasing frequency from a line batch. Domestic production of non-green glassware after 1860 is therefore more precisely described as lime-glass production or at least as flint and lime production.

It has already been pointed out that the census returns are not sufficiently detailed to permit an accurate appraisal of the trend of flint and lime glass production in the United States before 1880. In lieu of such evidence it is necessary to resort to indirect testimony. Between 1860 and 1880 the value of output of glass other than window or plate rose from $7,063,785 to $15,238,953, or 116 per cent.[108] It has been stated that the green-glass industry increased its capacity by 170 per cent between 1860 and 1882.[109] Therefore, if we assume that the capacity changes in both the green-glass and flint and lime glass industries had full effect upon value of output, and that no other factors were operative, it seems to follow, since the percentage increase of combined value of output was an average of the two individual rates of growth, that value of output in the flint and lime branch alone must have been between 60 and 70 per cent greater in 1880 than in 1860. It is probable, however, that this rate understates the amount of expansion that actually occurred, for pressed-glass prices were falling in this period in consequence of improvements in production methods. The value of non-green glassware produced in 1880 was reported at $9,568,520 and in 1890 at $18,601,244. The rate of growth of the flint and lime industry from 1880 and 1890 was thus slightly under 100 per cent.[110]

PROGRESS IN TECHNOLOGY

The explanatory factors in the continued expansion of the flint and lime branch of the glass industry of the United States

[108] *Eighth Census; Tenth Census.*

[109] *Report of the Tariff Commission, 1882,* II, 2509. I take this estimate as it stands. There is no explanatory comment by which one may appraise the accuracy of computation.

[110] *Tenth Census; Eleventh Census.*

resolve themselves largely into the progress of the pressed-glass industry. For three decades after 1860, this portion of the American glass industry led all others in technical achievement. The first improvement — the forerunner of many mechanical innovations — occurred in the then little understood realm of glass chemistry.

For the manufacture of bottles, window-glass, jars, and shades in England and on the continent of Europe lime glass has always been used, and can boast an antiquity perhaps as great as that of flint-glass. The first factories in this country made window-glass, using, of course, the lime composition; the manufacture of bottles followed, but flint-glass making was commenced, and, as in Europe, only inferior grades of ware were made of lime glass. In Pittsburgh, at an early period, common tumblers and cheap table ware were made of lime glass, and some improvement had been made in 1864; but still the lime goods were so much inferior to flint-glass as not to come in competition with it, their lack of purity and luster being very conspicuous faults.

In the winter of 1864 Mr. William Leighton, sr., of the firm of J. H. Hobbs, Brockunier & Co., made a course of experiments in the composition of lime glass, the result of which was so successful that the manufacture of lime glass was commenced by his firm, and ware was produced equaling in beauty the finest flint-glass. The most important feature in the composition of this new lime batch was the use of bicarbonate of soda in place of soda-ash, until that time universally used in lime glass; and this use of bicarbonate, and better proportion of all the materials, constituted the improvement, and led to the most important results. As the improved lime glass was much cheaper than flint-glass, being less than half its cost, other factories commenced using the same material and learned the new composition. The ware thus manufactured could only be distinguished from flint-glass by its less specific gravity, and by the peculiar tone of its sound when struck, the flint-glass having a full metallic tone or ring, while the lime glass emits a dull, dead sound destitute of vibratory tone.[111]

Leighton's successful explorations in the chemistry of glass, while not having exclusive application to glass manufacture by

[111] Weeks, p. 79, quoting W. Leighton, Jr., in the Wheeling, West Virginia, *Sunday Leader,* March 28, 1880.

pressing, nevertheless had a profound effect upon this branch of the industry. Prior to 1860 most pressed glass had been made from flint; after 1860 current practice was the contrary. But the use of lime instead of flint had consequences beyond mere reduction of metal costs. Lime glass possesses the property of chilling and becoming rigid more quickly than flint; it therefore became possible and even necessary to form and finish glass products more quickly than had formerly been the case.[112] This circumstance not only induced increased productivity in itself but acted as a spur to mechanical innovations which coincided with and reinforced the properties of the new metal. It was more than coincidence, therefore, that discovery of the new lime glass was followed by a series of significant mechanical innovations.

The glass manufacturers of the United States had long held preëminent rank in pressed-glass technology and technological improvement. Indeed from the industry's earliest years, diligent and continuous efforts had been directed to betterment of technique and process, and in this respect the achievements of the post-Civil War years constituted only an intensification of an evolutionary development which had its roots in the past.

The straight wooden press lever with its long reach and long return had at an early date been replaced by a more efficient weight-balanced curved steel lever affording a more convenient reach and shorter return. Next, spiral springs were incorporated in the body of the press to permit more careful pressing and quicker lever return. Then came the introduction of the "ring," a device which regulated the upflow of the pressed glass and reduced the work of rounding off the edges of the product to a short warming process called fire polishing.[113] Fire polishing itself was an American innovation rapidly and widely adopted between 1865 and 1880.[114] The adjustable mold guide and the water-cooled plunger were further innovations of the post-Civil War period. The solid metal plungers used prior to this time frequently became so overheated that they adhered to the glass.

[112] Weeks, p. 79.

[113] "Epochs in Glass-Making," *National Glass Budget,* XXI (December 9, 1905), 1.

[114] Weeks, p. 47.

When this happened it was necessary to stop work, clean the plunger, and cool it with water.[115] A further labor- and glass-saving device introduced after 1860 was the mold-heating furnace, which not only reduced the time formerly required to heat molds, rings, and plungers, and saved the glass wasted in the older method; but also exercised a beneficial effect upon technical operation through the temperature uniformity which the furnace imposed upon all mechanical parts requiring preheating.[116] Finally in 1886 a young moldmaker invented what was known as the "wind system." [117] The wind system was a more efficient method of cooling the pressing plunger, and though not generally utilized for some years after its introduction because of patent-rights problems, it eventually superseded the water-cooling system.

In the period 1860–1890 pressed-glass manufacturers and other subbranches of the American flint and lime glass industry benefited also from enlargement of pots and furnaces and the utilization of gas fuel. It was stated before the Tariff Commission of 1882 that "glassware manufacturers are nearly all . . . using gas furnaces." [118] The possibilities of the tank furnace in flint and lime production, however, seem to have been completely unexplored as late as 1890.

The passage of thirty years brought little technical progress in the manufacture of flint and lime glassware by processes other than pressing. Mold-blown glassware of both fine and inferior quality was made in much the same way before and thirty years after the Civil War, although molding devices underwent some improvement. It is also probable though not established by direct evidence that here, as well as in pressing, specialization of tasks was extended to a degree comparable to the development in the green-glass bottle plants.[119] Chimney manufacture,

[115] The task of cooling the plunger was assigned to the "carrying-in" boy who immersed it by pouring water from a cup fixed upon the end of a barrel stave (*National Glass Budget*, December 9, 1905, p. 1).

[116] *National Glass Budget*, December 9, 1905, p. 1.

[117] "The Great Wind System," *Commoner and Glassworker*, XXIV (October 18, 1902), 23.

[118] *Report*, II, 2139.

[119] It is known that this took place in non-green bottle manufacture. About 1870 there was considerable improvement in the quality of prescription bottles

a major sub branch of flint and lime production, experienced but one modification of process; in other divisions production methods seem not to have changed at all. Output of lamp chimneys, which had become consequential shortly before the Civil War, increased rapidly thereafter; in the decade 1880–1890 production reached its highest point, 40,000 dozen daily. Sometime after 1870 the crimped-top lamp chimney was introduced and in 1877 a crimping machine was invented at Pittsburgh.[120] The workers, however, refused to permit operation of the machine and to enforce their demand struck from June, 1877, to July, 1879. As a result of the bitter feeling thus aroused, the manufacturers were finally forced to install the machine at Chicago instead of in the Pittsburgh factories.[121]

THE RISE OF ORGANIZED LABOR

The first stages of the history of organization among the flint-glass workers of the United States cannot be described in detail or with precision. Some form of coöperative endeavor, perhaps partly social and partly beneficial, seems to have existed at an early date. Not until 1858, however, is there record of a formal union. At Pittsburgh in that year the Glass Blowers Benevolent Society was formed, but because of the unfavorable attitude of the employers the organization was held in utmost secrecy. After two unsuccessful strikes in the early years of the Civil War, like so many of the early glass unions, the Society disbanded. Local organizations apparently continued to exist, especially in the eastern cities, but no mutual program motivated their activities. In 1866 at the instigation of the Brooklyn workers, the first national convention of flint-glass workers was held at Philadelphia. Neither this nor the convention of the following year had tangible consequence. The first successful national convention, held at Pittsburgh in 1878, was composed of thirty-four delegates representing 1500 workers in the chimney, shade,

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produced. They became more uniform in size and weight, of better color, and were made with more easily dropping lips. ("Glass-Making in New Jersey," *National Glass Budget,* XXVIII [October 14, 1922], 14.)

[120] "The Lamp Chimney Industry," *National Glass Budget,* XXVI (April 29, 1911), 1.

[121] *National Glass Budget,* August 10, 1901, p. 1.

caster place, iron-mold, press, and prescription branches of the industry. The grouping of these several branches into one organization was effected through the Knights of Labor; henceforth the American Flint Glass Workers' Union of North America, a federation of craft unions, dominated the flint and lime branch of the American glass industry.[122] Subsequent conventions formulated regulations regarding output, length of working periods, and apprenticeship, but the rules and restrictions adopted varied appreciably among the constituent craft unions.

In the early years of pressed-glass manufacture the workers were not considered bona fide glassworkers. Nor indeed were they, for they were recruited from the ranks of intelligent but unskilled labor and paid as such. With the expansion of production that followed extension and increase of demand for pressed-glass products, however, both the general status and the wages of pressed-glass workers appreciated. After the Civil War wages of these workers and those in the traditionally recognized skilled glass trades tended to become more equal.[123] By 1877 some elementary labor-organization work had taken place and local restrictions had been imposed on the number of pieces made in a "move," or half-day's work. There was, however, no uniformity of these regulations in the several glass-producing areas. When membership in the American Flint Glass Workers' Union came in 1878, the men undertook concerted effort to make the output restrictions uniform. But the technical improvements of the post-Civil War years were at that very time motivating employers to break down these restrictions, and the following fifteen years witnessed a series of conflicts over the issue of worker productivity. The first struggle occurred over the desire of a Pittsburgh firm to use two molds instead of one in each "shop" or working unit. The lockouts which followed resulted in defeat for the glassworkers; output limits were thereupon increased although the principle of unlimited numbers per "move" was not fully established. Thereafter the workers slowly regained power

[122] "Flint Glass Organization, History and Progress," *Commoner and Glassworker,* XXIV (October 18, 1902), 3. In 1889 the union took membership in the American Federation of Labor.

[123] *National Glass Budget,* August 10, 1901, p. 1.

and "within a few years they had recovered sufficiently to put into operation rules prohibiting all overtime and all concessions to production, and providing for a cessation of work between June 30 and August 12 every year." In 1887 the workers scored a triumph — a complete list of moves, wages, and rules applicable to all factories. "The union now had a uniform wage scale; it had, moreover, a system of work that restricted production, and before the workers had resumed work after the contest, it was mutually arranged that, in order to avoid wage contests in the future, annual meetings between representatives of the employers and of the union would be held to try to amicably compromise their differences." [124] This relationship continued with good results until the strike of 1893.

Control of output and working conditions was achieved earlier and enforced for a longer period in the chimney-manufacturing branch than in the pressed-glass branch of the flint and lime industry, a circumstance at least partially explained by the fact that chimney blowers were "legitimate" glass blowers and hence in a stronger bargaining position than the pressers. The following is the statement of an old member and former official of the Flint Glass Workers.

From the time the manufacture of lamp chimneys became general in the United States . . . down to the present date, except for a brief period between the years 1872 and 1877, the output of lamp chimney factories has been restricted in various ways by the actions of the workmen, and from the time of the organization of all chimney workers into one general union in 1878 down to the present writing [1904] the tendency among the workmen has been to restrict more and more the production of chimney houses. Prior to 1878 it was not an uncommon thing for the workmen, at the request of their employer, to work some time beyond the limit of the understood day's work . . . With the formation of a general trade union among the workmen a disposition was manifested to take away the concessions to production. A schedule of numbers to constitute a turn's (one-half day's) work was adopted and a rule was put into effect limiting a week's work to eleven turns or five and one-half days; all overtime was prohibited . . . In 1883 the workers' union adopted what is known

[124] *Regulation and Restriction,* pp. 657, 658.

as the "summer-stop rule" which required all members of the union to discontinue work from June 30th to August 12, a period of six weeks. This added still more to the restrictions of the chimney department.[125]

Neither the glass pressers nor the chimney blowers seem to have attempted regulation of apprenticeship.

The situation in the flint-glass "prescription" department was closely similar to that in the green bottle branch. The following statement is also by a former official of the union, said to be one of the oldest and best informed men in the industry.

In the bottle department as late as 1860 there was a move system which prescribed a specific compensation for a fixed number of bottles. About that time or soon after bottles were placed on the absolute piecework basis with no limit as to the number of bottles to be made within a fixed number of hours per day, a rate per gross being established. This change was accompanied by some mild protest from the workmen, but there was no violent opposition, and the changed system except for a brief period in 1885–86 has continued uninterruptedly down to the present time [1904] . . . The effect of this change to an unlimited system in the bottle department was surprising and peculiar to all interested . . . The production was doubled, trebled, and in some instances quadrupled, and the peculiar feature of the change was that the enormous increase was made without appearing to have made employment scarce for the workmen.

There are several explanations for this peculiarity, however. The increased production cheapened the product and opened up new fields for its use, thus increasing the demand for bottles and making more work for the bottle blowers. Then the rush put upon the speed of the workmen by the change to an unlimited system incapacitated workmen from the arduous toil of the foot bench years sooner than the older methods of work would have done, and thus decimated their ranks to make room for new workmen.

Another thing aiding to keep the supply of labor nearly equal to the demand was the bottle blowers' apprentice restriction, still in force [1904], that prescribed that each factory should not take under instruction more than one person from each year to each twenty or fifteen journeymen workmen already employed.

[125] *Regulation and Restriction,* pp. 641–642.

Still another cause operating to prevent the supply of labor from exceeding the demand is what is known as the summer stop rule put forward by the workers, which requires all bottle blowers to discontinue the work of bottle blowing between July 1 and September 1.[126]

In the remaining divisions of flint and lime manufacture, restriction of output seems to have been the usual practice. The other types of regulation enforced in the individual craft unions already discussed were in general applicable to these also. In the shade and globe and caster place "departments," output had long been restricted to a fixed move. In the paste mold department as a whole, output was partly restricted and partly unrestricted; wherever the restrictions occurred they were imposed to protect similar articles made by other methods in other divisions of the union. In the iron-mold department, however, where all glassware showing a mold seam was made, production was unrestricted.[127]

PRODUCTION AND TARIFF PROTECTION

The tariff on flint and lime glassware imports was subjected to successive increases under the acts of 1861, 1862, and 1864.[128] The duty on plain, molded, or pressed glassware was raised from the previously prevailing level of 24 per cent first to 25, then to 30, and finally to 35 per cent. On articles of glassware cut, engraved, or otherwise decorated, and on Bohemian glass, paintings on glass, and all other glassware, these three acts applied rates of 30, 35, and 40 per cent. These duties remained in effect, except for the horizontal 10 per cent reduction of 1872–1875, until 1883. Appearing before the Tariff Commission of 1882, American manufacturers of flint and lime glassware other than pressed asked for at least 60 per cent protection. Instead, the duty on plain, molded, or pressed flint and lime glassware was raised from 35 per cent to 40 and the duty on articles cut, engraved, or otherwise decorated and all other glassware in-

[126] *Regulation and Restriction,* pp. 633–634.
[127] *Restriction and Regulation,* pp. 661–662.
[128] *Tariff Acts,* pp. 160, 205, 230.

creased from 40 to 45.[129] These provisions continued unaltered from 1883 to 1890.

From 1864 to 1890 American producers of flint and lime glassware enjoyed a tariff advantage ranging from 35 to 45 per cent. At the end of the period there was only one branch of the industry in a position to compete with foreign glassmakers on an equal basis. That there was a portion of the industry in such a condition cannot be attributed to the tariff, however; American pressed-glass manufacturers even before 1860 were producing with enough efficiency to permit substantial exportation. There is abundant evidence that America was a low-cost

TABLE 12

PRICES PER DOZEN OF PRESSED GLASSWARE, 1854–1888

	1854	1864	1874	1888	% of Price Fall 1854–1888
Goblets	$2.33	$3.50	$.78	$.40	83
Tumblers	.66	1.30	.55	.37	44
Wine glasses	1.25	1.73	.50	.30	76

Data from *National Glass Budget*, May 6, 1899, p. 1.

pressed-glass producer in the three decades before 1890. First of all there is the pertinent testimony of the course of domestic prices. In consequence of the chemical and mechanical improvements for which the period 1860–1890 is notable, the prices of glassware (largely pressed) in 1880 were far lower than they were sixteen years earlier; according to one source they were in some instances only one-fourth of the quotations of 1864.[130] Table 12 indicates the degree of reduction effected by 1888 in the case of certain pressed articles. The relatively moderate decline in the price of pressed tumblers is probably explained by the fact that the price of this commodity, one of the first to be made by pressing, had already been appreciably lowered by

[129] *Tariff Acts*, pp. 287, 315.
[130] Weeks, p. 79.

1854. More direct testimony of the favorable cost and price position of pressed-glass producers in the United States is found in the statement made before the Tariff Commission of 1882 that glassware prices in this country were at that time fully as low as in England.[131] Furthermore the pressed-glass manufacturers were about the only members of the glass industry who did not ask for increased tariff protection in 1882. True, they urged that the prevailing 35 per cent tax be retained, but this request appears to have been prompted by a fear that export of American glass-pressing machines would redound to their disadvantage by destruction of the export market and invasion of domestic selling areas.[132] Exports of domestic glass and glassware rose rapidly between 1861 and 1865, fell to 1871, and thereafter moved up at a slow but steady rate.[133] The important point for the purpose at hand, however, is to note that glass exports were reported to be primarily exports of pressed glassware.[134]

Throughout the period 1860–1890 America produced not only the cheapest but the best in pressed glassware. Mechanical and chemical innovations contributed to the maintenance of a competitive position which in 1860 had already been favorable. Moreover, wages paid pressed-glass workers had always been lower than those paid to artisans in other divisions of the glass industry and although in this period, stimulated by extension and increase of demand, the wage difference diminished, it seems not to have disappeared altogether.[135] Furthermore, the workers were unable to prevent, through restriction of the move and

[131] *Report of the Tariff Commission, 1882,* II, 2139.

[132] It has been said that export of American presses was largely attributable to the genius of Washington Beck ("Continuous Tank Furnaces," *National Glass Budget,* XXIV [January 22, 1909], 1).

[133] See Appendix, Table 2.

[134] "Some Domestic Glass Lore," *National Glass Budget,* XVIII (December 27, 1902), 1.

[135] *National Glass Budget,* August 10, 1901, p. 1. Despite the efforts of the union, money wages, at least as indicated in one piece of available evidence, do not seem to have been substantially increased between 1878 and 1894. At the first date the payments for 800 common tumblers were: presser, $1.92 per turn; finisher, $1.60 per turn; gatherer, $1.10. In 1894 the same shop made 1100 tumblers at each turn and the workers received $1.92, $1.65, and $1.25, respectively. (*Regulation and Restriction,* p. 659.)

other devices of limitation, increased productivity from becoming manifest in output. Uniform restriction of production seems to have been effectively enforced during a portion of the period, but in the course of conflict over such matters the moves were enlarged. In 1878 the move on common tumblers was eight hundred; in 1880 it was placed at nine hundred tumblers in five hours; just before the opposition to fixed moves was renewed by the manufacturers it had become one thousand tumblers in four and one-half hours.[136] American pressed glass was not only cheap; it also was of high quality, being particularly noted for purity of color and excellence of design and finish.[137] The American pressed-glass industry improved and grew between 1860 and 1890 and bettered its competitive position generally. There seems to be little doubt that the industry would have fared equally well had the United States been a free-trade country.

An appraisal of the status of the glass industry in an 1869 issue of the *Scientific American* points with pride to American achievements in glass manufacture by pressing.[138] It emphasizes, however, the fact that only in this field had domestic producers seriously attempted improvement. In a long list of subdivisions of the flint and lime industry, America was characterized as behind her European competitors. For example, though very fair plain window glass was then being produced, nothing had been done in colored window glass. In fine cut glass we were said to be unable to compete with France and England, or with Bohemia in fancy colored glass. Etched, painted, and gilded glassware as well as lighting equipment held an inferior position. In production of thin blown fine glassware the United States was also behind.

The *Scientific American* article describes a condition which appears to have been prevalent throughout the entire period 1860–1890. In the production of the finer types of glassware as well as in most of the other branches of the flint and lime glass industry except pressing, domestic costs were higher than foreign. In 1882 it was reported that foreign wages were two to

[136] *Regulation and Restriction,* p. 656.

[137] *National Glass Budget,* December 27, 1902, p. 1.

[138] "Glass Manufacture in the United States," *Scientific American,* XXI (October 23, 1869), 263.

four times lower than in the United States, that labor was about 90 per cent of total non-pressed glassware cost, and that American production of non-pressed glass was in consequence small and declining. Pure flint, it was said, was being made in small quantity; cut glass had fallen since the Civil War to an output equal to the capacity of a single furnace; chimneys and shades were being imported in great quantity (except in the case of coal-oil lamp chimneys, the greater part of which were made here); and ornamental glassware had just begun to be manufactured domestically.[139]

The import values of the various categories of flint and lime glass products reported in *Commerce and Navigation* also indicate that the pressed-glass industry was more advanced than the other branches of flint and lime manufacture. Table 10 in the Appendix shows that imports of decorated and fine glassware and of "unspecified" glassware (a category made up at least in part of flint and lime products) constituted a large part of total flint and lime imports from 1860 to 1890 and that their trend is continually upward. On the contrary, the series that probably contained a large portion of pressed-glass imports — plain glassware — is of much less importance as a segment of total flint and lime imports and has a trend moving sharply downward.[140]

The flint and lime glass industry of the United States enjoyed

[139] *Report of the Tariff Commission, 1882,* II, 2133–37. The price of lamp chimneys fell rapidly between 1854 and 1888. Prices per dozen were: 1854, $1.75; 1864, $2.25; 1874, $.50; 1888, $.30. The delivered foreign price was reported in 1882 to be about $.24 and foreign cost of manufacture $.12. (*National Glass Budget,* May 6, 1899, p. 1; *Report of the Tariff Commission, 1882,* II, 2137.)

[140] As in previous cases *Commerce and Navigation* tables do not classify imports in a manner contributory to precise analysis; the trends mentioned therefore are subject to qualification. It seems highly probable that the decorated and fine glassware series represented in large part non-pressed flint and lime imports, since the skilled labor necessary for cutting and decorating would be applied to blown and not to pressed ware. The series of unspecified glass is of uncertain constitution, but the fact that other classes of glass products — window, plate, and bottles — occur in their own series makes it probable that the unspecified series consists at least in part of flint and lime products. It seems certain that during most of the period pressed-glass imports were included in the plain glassware series. From 1861 to 1872 the designation of this classification is merely "plain glassware"; from 1873 to 1883 it is called "plain, molded or pressed not cut engraved, etc."; and from 1884 to 1890 "plain, molded or pressed flint or lime glassware."

more than moderate tariff protection between 1860 and 1890, yet the fundamental competitive relationships existing at the beginning of the period remained unchanged. America was then and in 1890 a low-cost producer of pressed glassware, although at both dates the opposite seems to have been true of other branches of the industry. A protective tariff was superfluous to the pressed industry, and since it was, consumers did not suffer. They enjoyed the facilities of cheap and efficient production.

In 1880 and 1890 domestic production of flint and lime glassware was 85 and 90 per cent of total consumption.[141] How much of this was attributable to pressed and how much to non-pressed production is not known. Since three-fourths of the weekly melt in 1860 was pressed and since this branch made great strides in the following thirty years, it seems reasonable to suppose that a very large share should be allocated to pressed glassware, a contention further supported by the information we have concerning the course of flint and lime imports. It is clear that the degree to which domestic production of non-pressed flint and lime glass in 1890 was extensive was attributable not to competitive advantage but to a protective tariff and that strong tariff protection sustained for thirty years seems not to have stimulated industrial improvement but retarded it. Furthermore, protection facilitated the regulatory activities of the American Flint Glass Workers' Union, and effective restriction usually meant further invariability from relatively high cost. To the extent that it was effective the tariff permitted continued high-cost production and subsidized high prices. The fact that it was not more generally detrimental is attributable to the efficiency of the American pressed-glass industry.

The Plate-Glass Industry

INDUSTRIAL DEVELOPMENT

In the process of manufacture, plate glass like pressed glass differed from the other branches of the American glass industry, all of which depended primarily upon the art and skill of the

[141] Flint and lime glassware

	1880	1890
Production	\$9,568,520	\$18,601,244
Imports	1,710,000	2,100,000

workers. The requirements of glass casting held the essential source of the dissimilarity, for casting was a process of relatively simple technique, requiring no intricate and adaptive manipulation, repetitive rather than discretionary. With no problem of highly skilled labor, an early opportunity for application of power and mechanization, and abundant and excellent raw materials and fuels, plate manufacture might have been effectively developed in the United States at an early date. In 1860 quite the reverse was true. Despite a decade of experimentation there was then only one American plate-glass factory with an output of negligible proportions. This same condition obtained until shortly before 1880. Ignorance of details of processes and, more important, failure to recognize the very factors in plate-glass manufacture which forecast its eventual success in the United States, account for the lethargic development. Stability in domestic plate production came when, and not before, the importance of large-scale production was appreciated and acted upon.

The lone plate-glass works operating in 1860, the National Plate Glass Company, continued to produce rough plate glass with indifferent success until the spring of 1865.[142] In that year its owners and certain other interested parties organized the Lenox Plate Glass Company. The goal of the company was the manufacture of polished plate and to this end they purchased the patent rights of an American inventor of polishing machinery — a man said to be the first American to experiment with devices for the improvement of the older French and English methods, and who had sold the rights of his first innovations to the British Plate Glass Company. All possibility of the success of the Lenox Company was dissipated by a disastrous adventure in the use of cryolite and the company failed in 1871.[143]

At this juncture appeared a key figure in the development of successful plate-glass manufacture in the United States. J. B. Ford was an intelligent entrepreneur of the most versatile type. In 1869 he became interested in plate glass, visited the Lenox

[142] "History of Glass Making: Plate Glass," *Glass Container,* March, 1927, p. 9; Weeks, pp. 98–99.

[143] Weeks, p. 99.

works, gained as much information as possible from the workmen employed there, and built a rough plate works at New Albany, Indiana. The best available grinding and polishing machinery was brought from England. At this establishment polished plate glass was first successfully and continuously manufactured.[144] Thenceforth, Ford built one new plate-glass works after another, managing each for a short time, then selling out to free himself for construction of larger and better plants, representing in every case successively greater capital investment. Although it was contended before the Tariff Commission of 1882 that "no plate glass had been made in America without loss to the maker prior to 1879," this necessary, if expensive, period of experimentation had by that time borne fruit.[145] In 1860 thirty thousand dollars' worth of rough plate was made in the single factory then existing; ten years later five plants had an output of $355,250, including both rough and polished plate, although the majority was probably rough plate. In 1880 there were six domestic producers responsible for a polished-plate output of $794,000. The Eleventh Census reported $4,172,484 in polished plate, and $781,550 in rough, cathedral, and skylight plate.[146]

In 1860 domestic production had been but 6 per cent of total consumption. Domestic production in 1890 constituted 82 per cent of consumption of unsilvered polished plate and 90 per cent of all types of non-polished plate.[147] Table 13 depicts with clarity the growth of the American plate-glass industry between 1860 and 1890. A $20,000 capital investment and fifteen work-

[144] Weeks, p. 99.

[145] *Report of the Tariff Commission, 1882,* II, 1530.

[146] *Eighth Census; Ninth Census; Tenth Census; Eleventh Census.*

[147]

Plate-glass imports		Domestic plate-glass production	
1860	$440,000	1860 (rough plate only)	$ 30,000
1870	1,450,000	1870 (rough and polished)	355,250
1880 (polished unsilvered)	757,000	1880 (total plate produced, not sold)	794,000
1890 (polished unsilvered)	917,000	1890 (polished)	4,172,484
(fluted, rolled, ribbed, or rough)	82,000	(cathedral, skylight, and rough)	781,550

ers epitomized the state of the industry in 1860. By 1890 there were 4,761 persons employed and $10,233,641 invested in capital equipment. The importance of large-scale operation is displayed by the capital investment per establishment. In 1860 and 1870 the units were $20,000 and $39,140; this period was one of experimentation and failure. By 1880, just prior to the era of successful plate-glass production, the average was over $400,000, and in 1890 when this country was supplying over four-fifths of its own consumption the unit size had increased by about 50 per cent.

TABLE 13

EMPLOYMENT AND CAPITAL INVESTMENT IN THE AMERICAN PLATE-GLASS INDUSTRY, 1860–1890

Year	Workers employed	Capital invested	Establishments	Capital investment per establishment
1860	15	$ 20,000	1	$ 20,000
1870	200	195,700	5	39,140
1880.	956	2,587,000	6	431,167
1890...........	4,761	10,233,641	16	639,602

Data from *Eighth Census, Ninth Census, Tenth Census, Eleventh Census.*

The growth of the American plate-glass industry between 1860 and 1890 followed lines of development which could well have been anticipated. Rough plate was undertaken first and by 1890 was 90 per cent of total consumption. Polished plate was attempted later but by the same date constituted 82 per cent of unsilvered plate consumption. Most of the polished plate produced between 1880 and 1890 was used for large window-glazing sizes, since demand for this type of plate was great and growing and since polished plate of a quality suitable for silvering (the production of which required great experience and care) could not then be made advantageously in American factories.[148]

[148] Clark, II, 502; *Report of the Tariff Commission, 1882,* I, 940.

THE PROCESS OF MANUFACTURE

No notable technical innovations were introduced in the American plate-glass industry before 1890. The development that occurred was based upon adaption of existing facilities and known and practiced processes.

The casting process employed in the early days was very crude.[149] The pot was removed from the furnace by tongs about twenty feet long. These were mounted on a "pot wagon" equipped with wheels near the center of its length. The pot was gripped by manipulating levers provided at the other end of the tongs, tightening the jaws on the pot. The carrying operation took about seventeen men, most of whom were used as counterweight on the end of the tongs to balance the pot. The gang of men, partly pushing, partly riding, conveyed the pot down the furnace hall to the casting hall, which usually was at right angles to the line of furnaces. Here it was picked up by the "teeming crane" — a jib crane mounted on a track that ran down the casting hall in back of the casting table — which was either pushed by hand or propelled by means of a winch mounted on the platform of the crane and connected by a chain to one of the axles. Four men standing on the platform and swinging the handles of the winch could move the crane to the proper position for casting. The pot hung by a chain from the jib of the crane, supported by tongs with long handles at each end known as teeming tongs.

The "teeming" or casting was done by the men on the platform of the crane, moving the crane and the pot transversely of the casting table and in front of the roller. The four men, two of whom were stationed at each end of the tongs, at a signal from the casting hall foreman (commonly one of the four workers) turned the pot over with a quick turn, at the same time swinging it in toward the roller, dumping and distributing the metal. After teeming, the roller was pulled over the molten glass, the power being furnished by men operating a winch. When the glass sheet was rolled, the roller passed off onto a carriage standing between

[149] The following sketch of the process of casting plate glass is from "Progress Made in Plate Glass Manufacture," *Glass Industry,* II (January, 1921), 3.

the casting table and the annealing kiln. The carriage was then pushed away to avoid interference with the sheet of glass going into the oven. In order to bridge the gap from the table and the floor of the kiln an "apron" consisting of wooden slats was laid across the space, one end resting on the floor of the kiln and the other on the casting table. An iron bar was then contacted with the head end of the glass sheet; this bar was itself attached by rods to a light wooden crossbeam which spanned the table. One worker at each side of the table grasped the wooden handles of the beam and four or five others, by joining hands, formed a line on each side and started the glass sheet into the oven. A second tool with an attached extension rod was used to push the glass farther into the kiln and another and still longer rod sent the sheet to the back to make room for two other glass sheets subsequently pushed in. The door of the kiln was then closed and the glass sealed in for two or three days. Withdrawing of the glass was done similarly. A worker crawled into the kiln and hitched a rope to the back end of the glass. By means of this rope and a windlass the glass was pulled out onto a movable table, cut for defects and picked up and carried by hand to the grinding shed. As many as sixteen men were used to transport the larger plates, some of which weighed as much as 1400 pounds.

One modification should be made in the above description. As late as 1884 the casting tables in at least some American plate-glass works were not provided with windlass and chain to draw the roller over the molten metal. In such cases, the roller was provided with hand holds and two lines of workmen, one on each side of the casting table, pulled it over the glass by sheer strength.[150]

The grinding and polishing phase of plate manufacture before 1890 followed the standard English practice. Indeed, it has been said that all the grinding and polishing equipment employed in this country was imported from England until a prospective American manufacturer visited that country and by subterfuge gained entrance to the famous Pilkington plant,

[150] "Early Plate Glass Making," *National Glass Budget,* XXI (September 9, 1905), 1.

where he carefully observed the grinding and polishing machinery, which he duplicated after his return to America.[151] In the period 1860–1890 in the United States the technology of this stage of plate manufacture remained imperfect. As late as 1885 in the plants at Creighton and New Albany some of the defective spots in the plate were rubbed out by hand.[152]

TARIFF POLICY

Imports of plate glass, polished and otherwise, had always paid tariff duty, but except for the brief period from 1842 to 1846 such glass was classified for tax purposes as imports of "all other glass and glassware." Prior to 1860, however, the duty on plate was not intended to be protective, nor was it. With the tariff of 1861 specified duties were for the first time since 1846 made applicable to plate glass. The classification, however, was coextensive with window glass. In 1862 the method of specification was revised; duties on rough plate were lowered somewhat from the level of the previous year but the rates on polished plate and silvered polished plate were substantially increased.[153] These duties remained in force for the entire period 1862–1890 except for the 10 per cent reduction operative from 1872 to 1875. Average ad valorem equivalents of the specific duties from 1870 to 1890 on fluted, rolled, or rough plate varied according to size from about 10 per cent to about 50 per cent, on polished plate unsilvered from 15 to over 100 per cent, and on polished plate silvered (including looking-glass plates) from approximately 20 to almost 70 per cent.[154] The majority of plate

[151] "A Plate Glass Pioneer," *Commoner and Glassworker,* XXII (August 24, 1901), 12.

[152] *National Glass Budget,* September 9, 1905, p. 1.

[153] *Tariff Acts,* p. 205; the individual duties in dollars per sq. ft. were as follows:

	Fluted, rolled, or rough	Polished, unsilvered	Polished, silvered
Not above 10 x 15 inches	.0075	.03	.04
Above 10 x 15, not above 16 x 24	.01	.05	.06
Above 16 x 24, not above 24 x 30	.015	.08	.10
Above 24 x 30, not above 24 x 60	.	.25	.35
Above 24 x 30	.02	..	..
Above 24 x 60	..	.50	.60

[154] See *Commerce and Navigation,* 1870–1890.

imports were in the larger sizes; the bulk of both rough and polished plate imports were included in the two largest brackets. Imports of silvered polished plate were more evenly distributed.[155]

Supported by average ad valorem tariff protection of about 30 per cent — the lowest of the glass and glassware duties then imposed — domestic production of unpolished plate glass grew from insignificance in 1860 to 90 per cent of total consumption in 1890. The vigorous growth of the rough plate industry owed perhaps some of its impetus to this relatively moderate tariff, which is in sharp contrast to other glass duties, particularly to the heavy rates on window glass. There are, however, other more significant factors contributing to the industry's expansion. Although wages for unskilled and semiskilled workers were higher in America than abroad,[156] the industry benefited from labor-saving devices, fine and cheap raw materials and fuel, and large-scale production. Many of the earlier industrial difficulties were overcome through the activities and foresight of J. B. Ford, the first manufacturer to begin plate-glass production on a large scale. The basic explanation of the rapid growth of the unpolished plate industry, however, lies in the industry's compatibility with the salient features of the domestic industrial economy, and especially with the features of the economy as it developed after the Civil War. This granted, it is to be conceded that tariff protection facilitated the development.

A similar conclusion follows from an analysis of the relations between the growth of polished plate production and the duties imposed upon foreign importation. Successful manufacture of polished plate came somewhat later and by 1890 had not advanced so far as rough plate production. At that date domestic production was 82 per cent of total consumption; thirty years earlier no polished plate whatsoever was produced in the United States. The technical difficulties were greater than in unpolished plate manufacture and, accordingly, only a relatively small segment of the potentialities latent in large-scale production and mechanization had been exploited by the end of the period under

[155] See *Commerce and Navigation*, 1870–1890.

[156] *Report of the Tariff Commission, 1882,* I, 1190.

consideration. Though the average of the ad valorem equivalents was higher than on rough plate, approximately 40 per cent instead of 30, imports were far more important.[157] Heaviest importation occurred in the two largest brackets and these brackets were those which paid the highest ad valorem equivalents. Heavy importation in the face of high duties indicates, unless the foreign commodity was of a very different type or quality, considerable difference between domestic and foreign costs and prices. Substantiation of this contention appears in the testimony before the Tariff Commission of 1882; Mr. W. C. De Pauw, then said to be manufacturing two-thirds of the plate glass made in the United States, states that the average selling price of polished plate glass was at that time $.60 per foot in England and $.90 in the United States, a difference of exactly 50 per cent. At the same time he testified that previous to domestic production the current selling price had been twice as great as it then was, a statement which if accurate strongly suggests monopolistic pricing practices, for foreign costs had not fallen to such an extent in the interval.[158] The foreign syndicates existing in 1882 may well have had sufficient power to engage in such manipulation.[159]

Since little if any polished plate of silvering quality was manufactured before 1890, the duties on foreign imports of this type had their primary and apparently sole effect upon revenue.

We may conclude, in summary, that tariff protection of the rough and polished plate-glass industry of the United States between 1860 and 1890 was coincident with notable expansion of domestic production, and that it was of uncertain necessity in the case of rough plate manufacture, though probably of greater consequence to polished plate, the more complex and technically difficult division of plate-glass manufacture. In both instances, however, there existed greater economic justification for temporary tariff protection than in any other division of the American glass industry.

[157] See *Commerce and Navigation* for the years indicated.

[158] *Report of the Tariff Commission, 1882,* I, 937; II, 1530–31.

[159] See the evidence in *Report of the Tariff Commission, 1882,* II, 1529–31.

ity or defect. Inventors of mechanical technique were faced with the necessity of developing adequate substitutes for the flexibility of the handicraft system.[2] A further barrier to mechanization of the glass industry lay in the range, flexibility, delicacy, and great variety of motion practiced in manual glass production.[3] To replace by machine the dexterity and flexibility of the human hand in these operations long seemed virtually impossible.

Only in the last half of the nineteenth century did inventive minds turn serious attention to the problem of mechanical glass production. The United States, however, was neither the sole innovator nor the sole experimenter; after 1850 in many countries there are records of early partial successes and of failures. It is true, nevertheless, that when mechanization was once begun in America it was carried on more rapidly, with greater enthusiasm, and with greater commercial success than in any other glassmaking country of the world.

The evolution of window-glass manufacture after 1890 may be divided into three well-defined phases. The first phase covers the years of turbulent intra-industry conflict from 1890 to 1903. The second, characterized by the advent of mechanization and the rise to preëminence of machine cylinder production, embraces the interval between 1904 and 1920, the end of the period of industrial expansion associated with World War I. The third phase comprises roughly the subsequent decade and is marked by the full triumph of mechanical revolution, displacement of machine cylinder methods by sheet drawing, and the complete disappearance of the ancient craft of hand window-glass blowing.

Prior to 1900 development of the American window-glass industry was in strict accord with the potentialities of forces operative in 1890. This period therefore witnessed continuous change of location, betterment of methods of fusing and fining, sustained operation of approximate bilateral monopoly, restriction of production, and control of prices. The reorientation of location under way in 1890 was pursued with increasing vigor in

[2] "Automatic Bottle Manufacture," *Glass Industry,* II (March, 1921), 55.
[3] *Glass Industry,* March 1921, p. 55.

the following ten years. The lure of natural gas in Indiana (increased by the offer of bounties of various sorts) brought to that state a vastly augmented number of window-glass houses and other glasshouses. In 1890 there were twenty-one plants in Indiana; by 1900 there were 110.[4] Meanwhile the number of factories in the neighboring state of Ohio had declined from sixty-seven, the high point of 1890, to twenty-eight. Natural gas and small-scale production thus induced the glass industry to retain its migrant character.

Widespread utilization of gas fuel went hand in hand with construction of tank furnaces. Though the new system of melting was still looked upon with intense suspicion in 1890, this prejudice was swept away in the great wave of development experienced during the next ten years. Although in 1890 there were few tank furnaces in American window-glass plants, five years later 60 per cent of domestic window-glass output was melted in this manner, and by 1900 they were in the window- and cast-glass industries 353 continuous tank furnaces with a capacity of 4834 pots. America did not invent the tank furnace and was slow to adopt it, but once cognizant of its practicability this country outran the world in its utilization.[5]

Industrial Strife

The two monopoly groups — manufacturers and labor — which before 1890 had been major factors in the course of window-glass prices and production played important roles thereafter; indeed, over a part of the period they were able to increase the extent of their power. Since 1880 the manufacturers had pursued restrictive practices through the medium of the American Window Glass Manufacturers Association. In the period 1893–1895, however, this organ of combination found itself in difficulty, being unable to maintain effective control. Accordingly, in 1895 a new organization known as the American

[4] *Eleventh Census;* Department of the Interior, Census Office, *Manufactures, Part III, Special Reports on Selected Industries, Twelfth Census of the United States, Taken in 1900* (1902), hereafter cited as *Twelfth Census.*

[5] C. M. Depew, *One Hundred Years of American Commerce* (1895), I, 281–282; "Continuous Tank Furnaces," *National Glass Budget,* XXIV (January 22, 1909), 1.

Glass Company was formed. This company was neither a producing nor managing unit, but a selling pool for 85 per cent of the window-glass factories then in existence. The American Glass Company dominated the industry more or less completely until 1899. In October of that year it was succeeded by the American Window Glass Company, a $17,000,000 corporation owning window-glass plants representing more than 70 per cent of the nation's total capacity.[6]

Labor, through L. A. 300, the other monopolistic factor in the industry, was able to maintain its share of regulatory power with greater success than the manufacturers. Rules and restrictions operative in 1890 were continued without substantial change or modification. Worker output, factory rules, length of blast, and settlement of wages, all seem to have been enforced with as much success after 1890 as before. The mechanism of annual conferences between representatives of L. A. 300 and the producers functioned smoothly and prevented industrial strife.

Because of the price policy pursued by the combination of manufacturers, the history of the window-glass industry after 1890 is marked by continuous effort on the part of the combination to eliminate both price cutting and the independent producers who recurrently appeared to take advantage of controlled prices and attractive profits. In 1897 somewhat more than two-thirds of total window-glass pot capacity was in the hands of the combine.[7] Approximately two years later the American Window Glass Company had jurisdiction over 1912 pots and fifty-three factories, twenty-three of which were listed as operating continuous tank furnaces. The independent operators exercised discretion over 462 pots and thirty-one factories, only four of which were reported to employ continuous tanks.[8] The monthly output of the glasshouses outside the American Window Glass Company, however, in 1899 was about 155,000 boxes a month, which with imports constituted an amount approximately equal

[6] "The Window Glass Combines," *National Glass Budget,* XVII (May 25, 1901), 4.

[7] "Window Glass Situation," *National Glass Budget,* XII (February 13, 1897), 1.

[8] "The Window Glass Combine Reaching Out for Independent Factories," *National Glass Budget,* XIV (February 11, 1899), 1.

to one-half of normal demand. Total productive capacity thus was obviously well in advance of national needs. Confronted by the problem of a dangerous number of competitors, and also troubled by a shortage of workers caused fundamentally by the union's restriction of apprenticeship, the window-glass combination resorted to an ingenious expedient. The American Window Glass Company entered into a contract with L. A. 300 by which a block of stock to the par value of $500,000 was placed in trust for the union, the stock to be paid for by accruing dividends and carrying with it representation on the board of directors of the corporation. The whole transaction was conditional upon the union's supplying the American Window Glass Company an adequate number of skilled glassworkers to run its plants during the length of fire agreed upon. L. A. 300 accepted the stock and elected its president, Simon Burns, as its representative.[9]

It should be noted that at this time the wholesale purchasers of glass, the jobbers, were also organized into an association. Moreover, this association was closely affiliated with the American Window Glass Company; in fact it was said to have been created at the suggestion of that corporation. As a result of these circumstances, the independent producers of window glass were faced, on the one hand, with the prospect of loss of workmen (there being an insufficient supply for all the factories) and, on the other, by the spectre of probable loss of their wholesale market. To avoid extinction they united in December, 1900.[10]

Like the old American Glass Company, the Independent Glass Company was not a manufacturing corporation but a selling agency designed to regulate the output of its members.[11] Each firm subscribed for shares on the basis of pot capacity, and the proceeds of the shares become a pledge or forfeit binding the firm to obey the orders of the board of directors. The entire product of each firm was turned over to the company and paid for at an agreed-upon rate. It then became the property of the

[9] *Regulation and Restriction,* p. 602. The stock was eventually forfeited because the union was unable to fulfill its portion of the contract.

[10] *Regulation and Restriction,* p. 602.

[11] The following discussion is based upon *Regulation and Restriction,* pp. 602–606.

company, to be sold, marketed, and handled with the product of the other firms. Each firm retained the management of its plant as before, except that the board of directors of the selling company had authority to designate the period of yearly operation. One representative from each firm composed the board of directors.

Combination among the independents themselves, however, did not guarantee a sufficient supply of workers. This difficulty was overcome for the independent producers, apparently fortuitously, by the first serious split in the ranks of L. A. 300. The dissension arose over the stock contract entered into with the American Window Glass Company. At first the newly formed organization of window-glass workers (the product of the split in the window-glass union) maintained that it was the rightful L. A. 300, but this contention being set aside by court order, it assumed the name Window Glass Workers Association of America. Hereafter members of L. A. 300 manned the plants of the American Window Glass Company and those belonging to the new organization manned the factories of the Independent Glass Company.

All elements necessary to severe conflict were now present within the glass industry, but strife was avoided by capitulation on the part of the American Window Glass Company. Upon display of strength among the independents, "realizing the folly of senseless competition, [it] joined with them in a share-and-share-alike agreement." Henceforth these two combinations of manufacturers, controlling about 90 per cent of the window-glass capacity of the country, proposed to coöperate with instead of opposing one another and to market all output through the jobbers' association. The National Wholesale Glass Jobbers Association was itself an organization of monopolistic character. It included every important jobber in the country, each of whom took stock in the association to the amount of $1500. The board of directors had authority, in case a jobber violated the rules regarding prices, to call for his stock, refund his money, and drop him from the organization. A jobber not a member of the association, or expelled from it, nominally could purchase glass from the combines, but only as a small purchaser at high prices;

practically, he could not afford to buy from them. Such jobbers could therefore buy only from manufacturers outside of the combines and these could not deliver large amounts of glass. The Jobbers Association made its purchases in a lump from the manufacturers and then apportioned the boxes among its members. The first purchase under the agreement between the Jobbers Association, the American Window Glass Company and the Independent Glass Company, was taken in January, 1901, at a price 30 per cent in advance of the preceding quotations; the supply of glass was furnished by the two combinations in a proportion agreed upon between themselves. A second purchase of the same year was made at a further advance of 25 per cent.

New conditions, unfavorable to the continuance of peace, soon appeared. Coöperative glass factories owned and operated by the workers, hitherto experimented with on a small scale, now multiplied rapidly to take advantage of high prices and the very sharp shortening of the yearly working period. This development was facilitated by the fact that a window-glass factory still represented a relatively small capital investment. Other outsiders also undertook construction, and by January, 1902, the two combines were said to have been operating but 60 per cent of the total number of pots in blast. The effects of expansion in an already over-developed industry interfered with the plans of both combinations and made necessary compromises with the new independents in regard to quantity of production.

Even greater difficulties arose. The Independent Glass Company withdrew from its agreement with the American. Then occurred a series of most unusual events. The American Window Glass Company, having been deserted by the Independent, joined forces with the Federation Window Glass Company, a selling agency organized by the coöperative factories to regulate output in a manner similar to the Independent Company. L. A. 300 manned the factories of the coöperatives. In order to contract production the American and Federated Companies in 1902 — as the American had done in 1901 — gave a 10 per cent advance of wages to L. A. 300 for enforcing a short blast. Despite these efforts, production in 1902 and 1903 was still far out of line with demand. In 1903 new conflict broke out among the

old and new window-glass unions over the question of whether the manufacturers should be aided in their attempts to restrict output, the old union favoring the manufacturers and the new organization opposing them. In consequence, wage scales were violated, manufacturers no longer maintained agreements and sold to jobbers as best they could, and the jobbers' association suspended activity. It was with the window-glass industry in this condition that machinery made its first thrust at the ancient art of window-glass blowing.

Production Methods, 1900

The nature and extent of improvement in the manufacture of window glass by about 1900 may best be seen in a description of a window-glass factory considered to be the most perfectly planned and thoroughly equipped in the world. The raw material used by the Chambers Glass Company at New Kensington, Pennsylvania, was carried from railroad cars to separate bins, from there mechanically conveyed to automatic mixers and apportioned, weighed, and mixed. The batch was then transferred by trolley to the filling end of the continuous tank furnace and deposited into hoppers, from which, by movement of a lever, the batch was dropped into filling-in shovels and emptied into the furnace. Two laborers unloaded all the material used in three tanks; two more laborers and one mixer constituted the mixing and conveying force for three tanks; one "filler-in" and one master teaser for each twelve-hour shift per tank performed all the operations involved in filling and melting. There were three main buildings, two of which, 100 x 200 feet and possessing attached wings 100 feet square, contained sixty-six blower tanks. The separate flattening house, containing fourteen of the seventeen flattening ovens and lehrs, was 100 x 750 feet, the warehouse 100 x 150, the clay house 120 x 180, and the mixing room 100 x 200 feet. The third and most modernly equipped building, 120 x 300 feet, combined under one roof blowing, flattening, and cutting departments. Its tank was of thirty-pot capacity and employed ten blowers on each eight-hour shift. By a departure in construction the gathering and blowing rings were separated. The former were arranged around the circular

end of the tank, five on each side, from the center back toward the fining chamber. Over the fining department five blowing rings were arranged on each side, the foot benches and swing holes being at right angles with them. As a consequence of this plan there were no separate blow furnaces; utilization of the heat of the tank for blowing out and opening the rollers saved both space and the fuel consumed by the blow furnace. Two flattening ovens, one single and one double, were situated about forty feet from the end of the tank. The double flattening oven was separated by a sheet conveyor. This conveyor was eighteen feet long, twelve feet of which were consumed by the outside fire or annealing chamber, the other six feet extending into the annealing oven proper. The oven was five-and-a-half feet long, eight feet wide, and nine feet high and was heated by gas jets suitably arranged beneath the receiving arms of the conveyor. The conveyor consisted of parallel endless chains running horizontally over sprocket wheels. Asbestos-lined iron perpendicular carrying arms, placed in a series of five about a foot apart, carried the flattened glass to the annealing oven after the glass had been piled flat on the conveyor at the level of the flattening stove. This annealing oven, known as the Lubbers, consumed much less space than required by the annealing of glass sheets by the old rod lehr method. The double flattening oven, single central annealing oven, and single conveyor, together made possible cheaper, quicker, and more efficient flattening and annealing.[12] These innovations, introduced in the American window-glass industry about 1896, were said to have reduced the labor required in this portion of the window-glass process by almost one-third.[13]

The preceding description makes two points clear. In the first place it is evident that considerable progress had been made in those phases of window-glass manufacture congenial to the type of industrial ingenuity characteristic of the United States, and secondly, that none of the innovations introduced had modified the fundamental process of window-glass forming. At

[12] This description taken from "New Flattening Ovens," *National Glass Budget,* XII (May 8, 1897), 1.

[13] "Window Glass Machinery," *National Glass Budget,* XII (May 1, 1897), 1.

the dawn of the twentieth century window-glass production remained substantially what it had been for centuries, an art and handicraft.

The Mechanical Revolution

In 1903 the Lubbers cylinder window-glass machine became a commercial success. About 1896, J. H. Lubbers, a window-glass flattener, began experiments with a device to blow air into a mechanism similar to a glass-blowing pipe raised on guides.[14] Under the auspices of the American Window Glass Company, much money and effort were expended in its development, and though the first machine was installed as early as 1900, it was not until three years later that the machine was deemed ready for commercial operation. Mechanical glass blowing, however, was neither a new nor a purely American conception. Robinet in 1824 used an air pump for blowing, and in 1854 Loup, another Frenchman, invented a machine similar to the Lubbers, employing simultaneous hand drawing and hand-pumped air pressure.[15] It is also recorded that in 1874 the "Window Glass Workers Union" forbade its members to work a cylinder blowing machine invented by Ralph Gray.[16] Still later, in 1886, M. A. Opperman, a Belgian glass manufacturer, devised another cylinder window-glass blower; this one used compressed air and mechanical drawing. Further efforts were made after 1886 but the Lubbers machine was the first to come into effective competition with the hand blowers.[17]

The process of making window glass by the Lubbers method substituted mechanical operations for the gathering and blowing formerly performed manually. Capping, splitting, and flattening of the cylinder all had to be performed by hand as before. The principal advantages lay in the fact that the machine dispensed entirely with the highly skilled services of the gatherer and blower and was capable of producing cylinders more than

[14] Fowle, p. 43.

[15] A. Silverman, "Fifty Years of Glass Making," *Industrial and Engineering Chemistry*, XVIII (September 1, 1926), 896.

[16] "The Machine Question," *National Glass Budget*, XIV (March 4, 1899), 1.

[17] J. F. Heffron, "History of Glass Making: Introduction of Machine Methods — Window Glass," *Glass Container* (December, 1926), 9.

twice the diameter and nearly five times as long as those made by hand.

The ingredients were melted as formerly and the molten glass was transferred from the refining chamber of the tank to a clay pot from which the glass was drawn.[18] This pot, with the aid of underneath blast fires, kept the glass at approximately the same temperature as in the tank. The blowing operation required the use of a "bait," a hollowed cast-iron cylinder drumhead equipped with an inner flange that filled with glass and formed the support of the cylinder to be blown. The hollow head of the bait was screwed onto a hollow pipe supported in a vertical position by means of a fork resting on an elevator or cage; the blowing pipe was attached to a long vertical base connected to a fan. Two motors furnished the air pressure and raised and lowered the cage. When the pot was filled, the cage, blowpipe, and bait were lowered to contact the glass. When the glass head in the flange had cooled, the cage started upward and blowing began. Under the increasing air pressure the cylinder, rising slowly out of the pot, was distended to the diameter desired, at which time the pressure was reduced to a point just sufficient to maintain this diameter. When the cylinder reached the length required, the speed of the machine was suddenly increased to thin the lower walls of the cylinder. This thinned wall was then cracked by a cold iron and the cylinder swung free of the pot. With the help of a hoop, cable, and pulleys, the cylinder, averaging from thirty-five to forty feet in length, was then dropped on a wooden "horse," capped, cut into smaller cylinders, and carried to the splitting room. There the cylinders were cut into segments or "shawls," usually three to a cylinder. The flattening, annealing, and cutting operations were identical with the hand method.

The number of workers employed in the machine cylinder process was considerably larger than in the hand process. The principal workers were the members of the ladle crew (the "ladler," the "skimmer," the "back ladler," and sometimes a "pot scraper"); the "blower" (the operator of the drawing and blowing motors); the "snapper" or "hooker" (the capper) and

[18] The following description is from *Productivity of Labor,* pp. 148–154.

the "splitters"; the "shove-in" boys and the flatteners; the lehr tenders; and the cutters. The cylinder machine not only dispensed with skilled labor but also integrated and specialized the other types of work involved in the process.

For several years after the introduction of the Lubbers machine confusion reigned in the American window-glass industry. Hardly had a period of relative stability descended than a further revolutionary glassmaking invention appeared. Its inventor, Irving W. Colburn, became interested in glass manufacture in 1898 and started a small experimental plant at Blackford, Pennsylvania, in the attempt to make a machine to blow lamp chimneys and tumblers.[19] This project, however, was abandoned in 1900. From 1901 to 1905 Colburn's friends helped him carry on experiments with a machine to blow window-glass cylinders but the device proved impractical because of the high cost of operation. In 1906 Colburn and certain backers formed the Colburn Machine Glass Company which proposed to produce window-glass by sheet drawing. Though the new process was thought sufficiently developed in 1908 to warrant granting of a commercial operating license, it was soon found necessary to conduct a long series of further experiments. In 1911 the Colburn Machine Glass Company failed. Through the efforts of M. J. Owens, however, the Toledo Glass Company in 1912 purchased at auction the foreign and domestic patents of the defunct concern. After four years of further experimentation at heavy cost, the Libbey-Owens Sheet Glass Company took over the Colburn patents and erected a six-unit plant at Charleston, West Virginia, where glass was first drawn in October, 1917. The process was a commercial success and in 1920 the capacity of the Charleston plant was doubled.

The preliminary operations of sheet drawing were similar to other methods of window-glass manufacture.[20] The molten glass moved from the melting portion of the tank furnace to the fining chamber and thence into a shallow drawing pan supported on silica brick stools with heat applied underneath to maintain temperature. To draw glass the machine was reversed and a

[19] This account is from Fowle, pp. 46–54, 58.
[20] The following description is from Fowle, pp. 59–65.

"bait" (an iron rod) was run down over bending rollers into the molten glass. When the bait had contacted the glass, the machine was started forward and a glass sheet pulled up and over the bending rolls, being kept a constant width by two sets of water-cooled rollers placed an inch or two above the surface of the molten glass just inside the edges of the drawing pot. The pulling was done by engaging the outer edges of the sheet, after they had passed over the bending rolls, between the flattening table and a series of grip bars running in the same direction and placed just above the flattening table. From the flattening table the sheet of window glass moved into a lehr composed of two hundred power-driven rollers covered with asbestos composition, and from this onto movable cutting tables. On these it was cut into suitable sizes, bathed in hydrochloric acid, and distributed to the cutting stalls.

Although the first successful commercial user, America was not the originator of the drawn window-glass process. The roundabout nature of both hand and machine cylinder window-glass production (in both cases glass was gathered, and a cylinder blown which had to be split, flattened, and cut before coming into the form desired) had tempted the ingenuity of a number of inventors before Colburn. Before 1860 William Clark had attempted vertical drawing, and in 1886 Prosper Haurez was experimenting with horizontal drawing. Paul Simon in 1902 and Emile Fourcault about the same time were working with horizontal and vertical machines, respectively.[21]

The advantage of the Colburn window-glass machine lay in the directness of its process, the consequent elimination of wasted time and labor, its freedom from the flattening faults and other defects of cylinder window glass, its uniformity and flexibility in thickness, and its natural fire polish. Furthermore, and highly important, the Colburn machine in the actual forming of the glass was practically automatic.[22]

When the American Window Glass Company began production on the Lubbers machine about 1903, the window-glass industry was already in a turbulent state. Combination of both

[21] "The Drawing of Sheet Glass," *Glass Industry*, II (August, 1921), 191.
[22] Fowle, pp. 64–65.

workers and manufacturers had broken down, prices and production were unstable, rival unions and manufacturers were fighting among themselves. Upon formal announcement that machine window glass was being successfully produced, panic spread among manufacturers and glassworkers. Both unions, which on hearing earlier rumors of mechanical production had taken a stand against it, reiterated their position.[23] At the time this attitude probably did not appear as futile as it in fact was. In 1904 there was still but one machine plant in operation. Its success, however, induced the American Window Glass Company to introduce the apparatus in other plants.[24] By 1909 one hundred and sixty machines were available, capable of producing almost half of the country's consumption.[25] The hand manufacturers, almost immediately after the announcement of successful mechanical production, sought to reduce cost to the level of the machine manufacturers; these efforts brought substantial reductions in wages. In this effort the hand producers were aided by the fact that the workers were in a weak bargaining position because of disunity; neither group dared to make serious efforts to resist wage cuts for fear its rival would underbid.[26] In 1903 it was estimated that a wage reduction of 40 per cent in addition to the termination of a previous advance of 15 per cent would enable the hand manufacturers to compete with the machine.[27] The difficult bargaining position in which they found themselves, epitomized by the wage reductions, forced the two window-glass worker factions to mend their differences. In 1904 a new organization, the National Window Glass Workers, took the place of the two older conflicting unions; the new union was able to offset partially some of the previous wage losses by increases negotiated in 1905 and 1906.[28] Meanwhile,

[23] *Regulation and Restriction,* pp. 612–613.

[24] *The Glass Industry, 1917,* p. 192.

[25] A. B. Morton, "Machinery in the Window Glass Trade," *The Johns Hopkins University Circular,* New Series, No. 4, April 1910, p. 43.

[26] "New Window Glass Problem," *Glassworker,* XXXIX (August 1920), 123.

[27] "Machine vs. Hand Labor," *National Glass Budget,* XVIII (March 28, 1903), 11.

[28] House of Representatives, *Tariff Hearings before the Committee on Ways and Means, 1908–1909, Schedule B* (1909), p. 1120; hereafter cited as *Tariff Hearings, 1909.*

however, labor for its own protection had decided to assist in the survival of the hand manufacturers; time-honored restrictions on output were therefore abrogated.[29]

By 1907 cylinder machine production had reached a state of near perfection and the machine producers thereupon attempted to take possession of the market by cutting prices below the cost of the hand producers. The industry was once more brought into a state of turmoil and as a result of this struggle many hand factories did not resume production for a number of years; conditions were so unfavorable that about half of them were said to be in bankruptcy in 1909.[30] Wages were reduced to the lowest level ever reached, for the union had been obliged in 1907 to base its rates upon a sliding scale dependent upon prices.[31] As prices fell in the price war, wages went down accordingly. "The average of wages was reduced from 90 cents per box in 1903 to 30 cents a box in 1912–13." [32]

The rise of the machine plants and the attempts of the hand producers to stay in business expanded productive capacity far beyond the degree necessary. When all members of the window-glass industry had been exhausted by the era of mechanical improvement and bitter competition, they resorted once more to combination. In 1909 the Imperial Window Glass Company was formed. Like its predecessors it was a selling agency, this time for all but six of the existing manufacturers. The American Window Glass Company, producing a large portion of the total output, was not in the combination but is said to have worked with it. After the formation of the combination, prices increased substantially. Profits were high in 1910 and as a result, in the autumn of that year, there were not six independents but fourteen, with five more building plants. The market was broken late in the fall of 1910 when, apparently for the first time, the restrictive activities of American window-glass manufacturers came under legal scrutiny. "In a suit

[29] Morton, p. 43.

[30] Morton, p. 43.

[31] Morton, pp. 42–43; *Tariff Hearings, 1909,* pp. 1120–21.

[32] *The Glass Industry, 1917,* p. 295; *Tariff Hearings, 1909;* House of Representatives, *Hearings before the Committee on Ways and Means, 1913, Schedule B* (1913), pp. 625–638; hereafter cited as *Tariff Hearings, 1913.*

brought by the Federal Government against the officers and directors of the Imperial Glass Co., the defendants, in November, 1910, pleaded nolo contendere and were fined."[33] Dissolution of the company followed.

From the fall of 1910 to the summer of 1912 there seem to have been free competitive conditions in the industry. Another selling agency, called the Johnston Brokerage Agency, was then formed and prices again went up. J. R. Johnston had been the secretary of the Imperial Company. This agency sold for about half of the hand window-glass plants and also for five companies using machines. It seems to have lasted for several years.[34]

After 1903 the machine cylinder window-glass plants continued to improve their equipment. Many minor though not unimportant labor-saving and cost-reducing devices were introduced. Mechanization changed American window-glass production from a small-scale, low capital investment industry to a large-scale industry, and with this metamorphosis came all the ancillary innovations attending large-scale production. But further than this the cylinder drawing machines themselves underwent improvement; new types also appeared. By 1908 two new cylinder machines, the Healy and the Douchamp, had been introduced. Still later there were others, the Frink, the Pittsburgh, the Okmulgee, and the Douchamp-Henshaw.[35] Individual instances of betterment of the process in general included the reversible double crucible, supports for lowering cylinders, electrically heated bars and nichrome wires for cracking, rotating ovens for flattening, and continuous lehrs for annealing, an important type of the last being the muffle lehr, which by a system of radiation afforded a high degree of heat uniformity.[36]

In 1917 the Colburn process was added to mechanized window-glass production and though significant progress had been made by 1920, the full impact of this invention came later. Up to 1920, the triumph of the machine in window-glass manufac-

[33] *The Glass Industry, 1917,* p. 190.
[34] *The Glass Industry, 1917,* p. 190.
[35] *The Glass Industry, 1917,* p. 190.
[36] Silverman, "Fifty Years of Glass Making," *Industrial and Engineering Chemistry,* XVIII (September 1, 1926), 896.

TABLE 14

MECHANIZATION OF THE AMERICAN WINDOW-GLASS INDUSTRY

Year	Total cylinder and sheet machines	Cylinder machines	Sheet machines	Hand pots	Estimated percentage of window glass produced by hand method[a]
1900	0	0	0	..[b]	100
1903	24	24	0	..[b]	..
1904	[b]	.[b]	0	2,280	.
1905	124	124	0	2,342	..
1906	..[b]	..[b]	0	2,772	..
1907	130	130	0	2,881	..
1908	..[b]	..[b]	0	2,699	..
1909	160[d]	160[d]	0	2,391	..
1910	116	116	0	2,315	..
1911	128	128	0	2,438	50[c]
1912	128	128	0	2,257	..
1913	162	162	0	1,564	.
1914	155	155	0	1,452	44[c]
1915	284	284	0	1,625	33⅓[c]
1916	308	308	0	1,913	39
1917	327	321	6	1,826	..
1918	318	312	6	1,903	..
1919	350	344	6	2,108[e]	34
1920	335[d]	329[d]	6	2,367	..
1921	341	329	12	2,735	..
1922	344	324	20	2,660	..
1923	310	284	26	2,101	24
1924	335	257	78	1,300	..
1925	348	264	84	888	6
1926	344	269	75	567	2
1927	339	265	74	186	..
1929	177	60	117	..[b]	..

Data from Harry Jerome, *Mechanization in Industry* (1934), pp 100–101. Jerome's data are from various sources.

[a] Estimates not strictly comparable since from a variety of sources.

[b] Not reported.

[c] Estimates from *National Glass Budget*, June 10, 1911, July 5, 1919, January 10, 1920; *Glassworker* May 1915, October 9, 1915.

[d] This figure is in conflict with that cited in text, but the discrepancy is slight.

[e] From 1919 to 1925 a scheme of production control was in operation and half of the total number of pots worked during the first half of the year and half during the second. Therefore from 1919 to 1925 about half the number of hand pots reported were in actual operation at any one time.

ture was steady but less complete than might have been expected (see Table 14). In 1904 there was but one machine plant; five years later 165 machines were producing almost 50 per cent of total output. In 1911 the output produced mechanically was 50 per cent, in 1913–14 it was 56, and in 1915 it was 66⅔.[37] By 1919 no further gain had been made, two-thirds of productive capacity still being allotted to machine factories; in 1920 the total number of machines was 325 (335, according to some sources), representing six different types.[38]

The explanation of the continued existence and operation of the hand factories lay in the industrial expansion characteristic of the period of World War I. This expansion gave producers by the old method a new lease upon life and for a time it almost seemed as though manual and machine manufacture would be able to exist side by side.[39] The hand production of these years, however, was not the hand production of pre-machine days. The power formerly wielded by L. A. 300 over wages and output no longer existed. Indeed, only because of this circumstance were the hand plants able to survive even temporarily and in a generally high-price period. Before and during World War I there were three unions in the window-glass industry: the National Window Glass Workers, the Window Glass Cutters' and Flatteners' Association of America, and the Window Glass Cutters' and Flatteners' Protective Association of America. The last two were identified with machine production, the second working in the so-called independent machine plants and the third in the plants of the American Window Glass Company. The National Window Glass Workers, the heir of L. A. 300, embraced all four skilled trades and was the only organization of the workers in

[37] "Window Glass in the Making," *National Glass Budget,* XXVII (June 10, 1911), 1; "Window Glass Production," *Glassworker,* XXXIII (May, 1915), 1; "Why Window Glass Manufacturers Stood Firm at Conference," *Glassworker,* XXXIV (October 9, 1915).

[38] "Munro's Remarkable Talk," *National Glass Budget,* XXXV (July 5, 1919), 1; "Survey of the Glass Industry," *National Glass Budget,* XXXV (January 10, 1920), 1.

[39] *Glassworker,* August 28, 1920, p. 23; E. W. Tillotson, Jr., "Manufacture of Constructional Glass in the United States," *Journal of the Society of Chemical Industry,* XL (1921), 155T. Note the increase in number of factories between 1914 and 1919 in Table 15.

hand plants; though it still exercised considerable influence it possessed but a shadow of its predecessor's grandeur. An indication of this is the circumstance that in 1918 cutters' and flatteners' wages were the same in both machine and hand factories and the machine "blower," who was not a blower at all but a machine operator, earned as much or more than the hand blower.[40]

The Triumph of the Sheet Process

The history of window-glass manufacture in the decade after 1920 is notable for the remarkable change in the proportion of window-glass production attributable to the two basic types of machines in operation in 1920. In that year, though two-thirds of total output came from machine factories, there was but one sheet-drawing plant and an almost negligible portion of glass made by the sheet process. Cylinder machine window-glass production was paramount. After 1920 this situation was gradually reversed as is indicated in Table 14 by the number of machines of both types in operation. In 1920 there were 329 cylinder producers and only six sheet-drawing devices; by 1929, on the contrary, 117 sheet-drawing machines were recorded and only sixty cylinder blowers. In 1926 cylinder machine output had declined to slightly over 59 per cent of the total, but the greatest shift came in the following three years. In 1929 the share of the cylinder machine method had fallen to fractionally over 20 per cent. The fate of the sheet-drawing process was exactly the reverse: by 1926 almost 40 per cent of total domestic production was being made by this method and by 1929 more than 79 per cent. Of the sheet-drawn percentages the Libbey-Owens, or Colburn, invention held about 29 per cent in 1926 and over 35 per cent three years later.[41] Most of the rest of the drawn-glass output came from American factories which had bought the operating rights to the Belgian Fourcault machine, which had been patented in 1902 but did not come into wide-

[40] "The Window Glass Industry," *National Glass Budget*, XXXIV (September 7, 1918), 1.

[41] United States Tariff Commission, *Cylinder, Crown and Sheet Glass*, Report No. 33, 2nd Series (1930), p. 7; hereafter cited as *Cylinder, Crown and Sheet Glass, 1930*.

spread use in Belgium until after the end of World War I.[42] The Fourcault was one of the simplest and most efficient of glass-drawing inventions, and was superior to the Colburn in that it drew perpendicularly and hence avoided the turning of the glass sheet into a horizontal position. Its use is reported to have permitted a direct labor-cost saving of 69 per cent over the hand cylinder process on single-strength glass and 67 per cent on double-strength. The Colburn method may have been somewhat less efficient than this because 44 per cent of total window-glass production in 1929 was made by the Fourcault machine, which had accounted for but 10 per cent in 1926. In the later years of the period after 1920 other inventions lengthened the list of drawing-machines used in the United States. In consequence of the simpler, more direct, more efficient, and more economical features of drawn window-glass, cylinder window-glass production in the United States eventually disappeared altogether.[43]

A second feature of American window-glass manufacture after 1920 was the elimination of hand window-glass production in the United States. This eventuality could well have been anticipated from the progress achieved prior to 1914, but the increased demand for American window-glass during the period of World War I served as a temporary commutation of the death sentence given the window-glass blowers; the events which transpired upon the return of peace, however, made their elimination inevitable. In 1926 a mere 2 per cent of total output was attributed to hand production; in 1929 there was none. The dissolution of the National Window Glass Workers in 1928

[42] *Cylinder, Crown and Sheet Glass, 1930,* p. 7. The principles of the Fourcault were analogous to those employed by the Colburn method which has already been described. For two excellent detailed descriptions of the Fourcault system see "The Drawing of Sheet Glass," *Glass Industry,* II (August, 1921), 191, and *Productivity of Labor,* pp. 155–158. By 1928 the success of the Belgian invention had reduced the field of hand production in Belgium to 16 per cent of total output ("Developments in the Belgian Glass Industry," *American Glass Review,* XLVIII [October 6, 1928], 27).

[43] The direct labor-cost saving over the cylinder process effected by the Fourcault was 27 per cent on single strength glass and 30 per cent on double (*Productivity of Labor,* p. 161).

symbolized the demise of the once highly honored and highly paid craft of window-glass blowing.[44]

Tariff Protection

The window-glass industry of the United States continued to enjoy heavy tariff protection after 1890. The duties on cylinder, crown, and common window glass, plain and processed but not polished (the major item in imports during these years), varied little between 1890 and 1920. The act of 1890 modified the provisions of 1883 by slightly increasing the duties on the largest sizes of glass and by imposing a 10 per cent additional tax upon window glass, ground or otherwise processed, ornamented, or decorated. The tariff act of 1894 made reductions on all sizes but retained the 10 per cent differential; this act, however, was in force only three years. The tariff of 1897 restored the rates of 1890 except those on the larger sizes; these rates were reclassified and increased and a 5 per cent differential was substituted for the 10 per cent differential. In 1909 the rates on the first three sizes were varied according to value but were not increased above those prevailing previously.[45] The duties in the higher brackets were reduced slightly. The tariff act of 1913 made the first substantial reduction in unpolished window-glass rates since the Civil War; sharp cuts were made applicable to all brackets and the 5 per cent additional duty was dropped to 4 per cent.[46] The average ad valorem equivalent for the entire period 1890–1920 on plain unpolished window glass amounted to roughly 60 per cent and on processed glass to about 40 per cent.[47]

The reduced window-glass duties of the tariff act of 1913 were

[44] "National Window Glass Workers to Quit," *American Glass Review,* XLVII (June 16, 1928), 17.

[45] *Tariff Acts,* pp. 369, 465, 545, 700.

[46] House of Representatives, Committee on Ways and Means, *Comparison of Tariff Acts of 1913, 1922, and 1930,* 71 Cong., 2 Sess. (1931), p. 26; hereafter cited as *Comparison of Tariff Acts.*

[47] *Commerce and Navigation,* 1890–1920. The remaining and minor portion of window-glass imports, those of polished cylinder and crown, and silvered polished cylinder and crown paid lower average ad valorem equivalents than those cited above.

abolished by the law of 1922 and heavier duties put in their stead. The average increase on plain unpolished glazing glass approximated 30 per cent, but the new impositions relatively were higher on the small sizes than on the large.[48] These tariffs remained effective until June 13, 1929, when by presidential proclamation they were once more augmented, this time by 50 per cent. The net general effect of changes made from 1922 to 1929 was to place the duties on plain common window glass on a level not far from equal to that of 1909 (the duties on the smaller sizes were in fact higher than in 1909 but those on the larger were less). The ad valorem equivalents of the plain window-glass duties averaged, for all sizes, approximately 25 per cent from 1920 to 1922 and over 45 per cent from 1923 to 1929.[49]

The tariff protection enjoyed by the American window-glass industry from 1890 to 1903 was consistent and heavy.[50] In addition, production during this period was aided by the adoption of continuous tanks and gas furnaces and the installation of labor-saving devices in the preparatory phases of manufacture. In 1899 an authoritative source reported that domestic sand, lime, and soda were as cheap as in Belgium (a principal competitor in window-glass production), that fuel was not only cheaper but better, that tank furnaces were equal and in many cases superior to the average used abroad, that flattening ovens were as good and lehrs better, and that the window glass produced domestically — except some made in the smaller factories and poorly assorted — was clearer and freer from imperfections than the average imported.[51]

In spite of the protectionist shield held over the window-glass industry during the period, the improvements made and the

[48] *Comparison of Tariff Acts*, p. 28.

[49] *Commerce and Navigation*, for the years indicated. Other types of window glass were relatively unimportant in the total of window-glass imports in this period. In general, it may be said that the ad valorem equivalents of the specific taxes on these other types were lower than those on plain window glass.

[50] Throughout this section analysis is focused on imports and domestic production of window glass as a whole and especially upon the major item in both of these, unpolished, or plain, window glass.

[51] "An Expanded Window Glass Market," *National Glass Budget*, XV (December 9, 1899), 1.

TABLE 15

TOTAL PRODUCTION, AVERAGE UNIT VALUES, AND IMPORTS OF WINDOW GLASS, 1890–1929

Year	Total Production: Number of establishments	Total Production: Value (dollars)	Total Production: Quantity (sq. ft.)	Total Production: Increase in quantity (per cent)	Index of average unit values[a] (per cent)	Bureau of Labor Statistics wholesale price index (per cent)	Total imports of window glass[b] (dollars)	Domestic production as percentage of imports plus domestic production
1890	84	9,037,187	188,444,200	..	96	..[d]	3,000,000	75
1899	100	10,879,355	217,064,100	15	100	100	1,770,000	86
1904	103	11,986,881	249,693,150	15	96	109.8	1,750,000	87
1909	..[c]	11,742,959	346,080,550	39	68	124.6	970,000	92
1914	64	17,495,956	400,998,893	16	87	128.7	1,310,000	93
1919	79	41,100,724	368,912,209	−8	222	273.4	130,000	99.7
1921	..[c]	24,026,366	260,065,080	−29	184	188.2	2,820,000	89
1923	65	42,623,203	510,214,838	96	167	188.7	2,890,000	94
1925	42	37,524,728	567,150,590	11	132	203.3	2,930,000	93
1927	23	26,813,507	481,021,350	−15	111	..[d]	3,280,000	89
1929	20	25,962,167	402,558,961	−16	129	..	2,770,000	90

Data from *Productivity of Labor in the Glass Industry* and Census of Manufactures for the years specified; import data from *Commerce and Navigation* for the years specified.

[a] Index of average unit values computed on 1899 base.
[b] Import figures rounded to nearest $10,000.
[c] Not reported
[d] Index of wholesale prices is one recomputed by the compilers of *Productivity of Labor in the Glass Industry* and therefore cannot be continued.

economies achieved up to 1903 brought no notable increase in domestic production. Nor was there exerted any effective downward pressure on prices. The two monopolistic elements in the industry obviously were operating with substantial effectiveness. Table 15, which presents a statistical history of the American window-glass industry after 1890, shows the changes that occurred in value and quantity of production. Both in the nine-year period between 1890 and 1899 and in the five-year period between 1899 and 1904 quantity of domestic output increased 15 per cent. From 1880 to 1890 the comparable rate of growth had been over 100 per cent.[52] In 1890 there were 84 establishments reported, in 1904 there were 103, and the productive capacity of each firm had meanwhile been considerably enlarged. Actual production gave inadequate evidence of such development. Moreover, the average square-foot value of output in 1899 was higher than in 1890 and in 1904 it was precisely the same as fourteen years earlier. The high tariff permitted restricted and high-priced domestic production to rise from 75 per cent of combined imports and production in 1890 to 87 per cent in 1904, in terms of value.

In 1901 it was reported in a trade journal loyal to the interests of the American window-glass industry that window-glass prices were then twice as high as in 1897 and higher on ordinary sizes than in 1860 and 1890.[53] The same authority states that in no other American industry had prices been adjusted to the cost of imported commodities with such precision as in the window-glass industry.

One may well ask how there could have been any imports at all with so high a tariff in effect. The importation that took place had two fundamental explanations. In the first place, foreign producers, especially Belgian, enjoyed excellent local transportation facilities and very cheap ocean freight rates, and in the second place, although wage rates paid in the United States for the blowing of small window glass were particularly high com-

[52] The monopolistic elements in the industry were at work in this period also but, whether from choice or circumstance, obviously pursued a less restrictive policy than during the interval 1890 to 1903.

[53] *National Glass Budget,* May 25, 1901, p. 4.

pared to foreign countries, American workers could earn a still larger total income by blowing large-size glass. Consequently a major part of total imports were made up of window-glass sizes below 16 x 24, in the production of which foreign producers possessed a peculiar advantage and domestic producers a peculiar disadvantage.[54]

Because of the shipping advantages of foreign window-glass producers, American manufacturers, even with the substantial tariff protection they enjoyed, could not bar foreign window glass from the coastal areas.[55] They could, however, include this competitive circumstance in a system of price control. The United States, it is reported, was divided into six districts for pricing purposes. In each district price was determined by the cost of imported glass in that area. Prices in the interior were higher than on the coasts; customers at Pittsburgh at one time were said to have been required to pay $.14 per box more than purchasers at Boston and $.20 more than purchasers at Philadelphia.[56]

From 1890 to 1903 the two monopolistic factors in the American window-glass industry are reported to have drawn substantial profits from exercise of their power. It has been estimated that wages, the sole element of high-cost production remaining at the beginning of the twentieth century, were anywhere from two to four times greater than foreign.[57] Table 16 demonstrates the wage advantage enjoyed by the window-glass workers over other groups of glassworkers. A portion, perhaps a considerable portion, of the difference between American and foreign wages and between window-glass wages and wages earned by other American workers probably should be classed as monopoly return. The extent of gain to the other restrictive element of the

[54] *National Glass Budget,* September 7, 1918, p. 1; *Regulation and Restriction,* p. 606; "Window Glass Imports," *National Glass Budget,* XVIII (May 16, 1903), 1.

[55] "Expansion of the Window Glass Market," *National Glass Budget,* XV (November 18, 1899).

[56] *National Glass Budget,* May 25, 1901, p. 4.

[57] "Window Glass Importers," *National Glass Budget,* XII (October 10, 1896), 1; *National Glass Budget,* December 9, 1899, p. 1; "Changes in Window Glass Manufacture During Three Centuries," *National Glass Budget,* XVI (January 19, 1901), 1; *National Glass Budget,* May 16, 1903, p. 1.

window-glass industry, the combination of manufacturers, is said to have been great; for example, profits were reported at $700,000 in 1896, at $1,750,000 in 1897, and at $2,100,000 in 1898.[58]

Mechanical revolution dominated the history of the American window-glass industry in the interval from 1904 to 1913. Its imprint is evident in quantity of output, average value of output, wages, imports, and exports (see Table 15). Quantity

TABLE 16

WAGES AND HOURS IN THE AMERICAN GLASS INDUSTRY, 1904

Trade	Hours of labor per week	Wages per hour
Green-glass blower	51.00	$ .6078
Flint-glass blower	50.12	.5768
Flint-glass gaffer	49.41	.5790
Flint-glass gatherer	49.48	.3201
Window-glass blower	36.78	1.1740
Window-glass gatherer	36.67	.8529
Window-glass flattener	68.00	.5868
Window-glass cutter	58.00	.4832

Data from Morton, p. 39.

of output increased 39 per cent in the five-year period from 1904 to 1909 and the proportion of imports plus domestic production supplied by home producers rose from 87 to 92 per cent. Average value per square foot fell almost 30 per cent in five years. Imports fell from $1,750,000 in 1904 to $970,000 in 1909 or by 44 per cent, though the tariff had not been increased. Exports of window glass, which had been insignificant before 1897, increased their rate of augmentation decidedly after 1909.[59] Wages tumbled, the union relinquished its traditional limitation of output, productive capacity increased, profits of

[58] *Commoner and Glassworker,* October 1899; *National Glass Budget,* January 19, 1901, 1; "The Tariff on Window Glass," *National Glass Budget,* XVII (May 25, 1901), 1.

[59] See Appendix, Table 4.

the hand manufacturers disappeared and were replaced by losses and bankruptcy — the disruption attendant upon violent change was rampant. Price competition instead of control was the common practice until 1909. In that year there were renewed attempts at combination among producers, and the at least partial success of the movement may be indicated by the fact that the average square-foot value rose by 28 per cent between 1909 and 1914, while the index of wholesale prices was advancing by only slightly more than 3 per cent. Had free competitive conditions prevailed throughout these years, average values should have shown either no change or, at most, a small rise, for nothing seems to have transpired to cause any other trend. Even if prices in early 1909, as a result of the preceding price war, had been below the cost of the machine producers as well as the hand producers, the point of equilibrium should not have been so near the level of 1904. It has been estimated that the introduction of the cylinder-blowing machine resulted in a direct labor-cost reduction of about 53 per cent for single- and double-strength window glass combined.[60] The approximate 30 per cent fall of average values which occurred between 1904 and 1909 therefore would seem to have been normal and the following 28 per cent rise abnormal.

The tariff act of 1913, making substantial reduction in the window-glass duties, was prevented from providing a test of the strengthened competitive position of the American window-glass industry by World War I. By the time the rates did become effective, the foreign window-glass situation had altered and also the relative position of the American industry. During the course of World War I the glass industry, like so many others, underwent notable expansion. This is not apparent in Table 15, since production for the war years is not reported. Production of window glass in 1919 was lower than in 1914 and the average value figure approximately two and one-half times that of 1914. By this time, however, the window-glass industry in the United States had been in large part transformed. Essentially an art and handicraft in 1903, by 1920 it had assumed many of the characteristics of the system of production for which America

[60] *Productivity of Labor*, pp. 159–160.

has become famous, being two-thirds mechanized, using much capital, producing on a large scale, and emphasizing the aid of many labor-saving devices — in short, it was no longer dependent upon the deftness and skill of the human hand.

It will be noted in Table 15 that domestic window-glass production was maintained at a very high level from 1921 to 1929. Average unit values meanwhile moved downward at a rapid pace both absolutely and relatively, a circumstance which reflected a generally improving cost position of domestic manufacturers and, specifically, the triumph of the sheet-drawing processes and full mechanization of the industry. Imports, however, also rose sharply and remained at high levels up to 1929. In consequence, the ratio of imports to total domestic production mounted, but not sufficiently to destroy the home manufacturers' mastery of local markets. It thus appears that despite continuous improvement, full mechanization, and falling costs and prices (and also high tariff protection), the relative competitive position of American producers was no more favorable after 1920 than in 1909 and 1914. For this condition there are several explanations.

In the first place, though America kept well in advance of Europe in mechanical window-glass production prior to World War I, thereafter revivification of foreign (particularly Belgian) window-glass manufacture and its transformation by machine methods substantially reduced the advantage that domestic producers had achieved.[61] Furthermore, the advantageous transportation cost situation for foreign shipment to American coastal cities continued to operate after 1920 and helped to maintain the potential of European competition. According to a Tariff Commission report applicable to this period, transportation charges on Belgian glass to New York, New Orleans, and San Francisco were substantially less than the domestic rates from home producing areas to those points, and similar situations obtained in other markets similarly located. In the interior areas, however, foreign competition was practically non-ex-

[61] *American Glass Review,* October 6, 1928, p. 27; "Tariff Commission Soon To Take Final Action in Window Glass Cost Inquiry," *American Glass Review,* XLVIII (January 12, 1929), 23.

istent. It was this relationship of delivery costs that accounted for the fact that practically all imported window glass was consumed on the east and west coasts.[62]

A third explanation of increased window-glass imports after 1920 lay in the activities of foreign window-glass combinations. Prior to World War I syndicates organized for control of sales, prices, and production influenced the window-glass industry in many European glass-producing countries. These were reported operating with varying degrees of success in England, Germany, Austria, France, Italy, Portugal, and Belgium.[63] The Belgian organization was apparently the most effective; it was said to comprise all manufacturers. Minimum discounts (that is, selling prices) for different countries were allegedly based upon reports of the degree of competition in those countries. If, for example, it was discovered that competition was not severe in certain areas, prices were raised; if conditions were more unfavorable, prices were lowered. It seems well established that after 1920, as before, the foreign syndicate system was an important factor in window-glass imports into the United States. It is interesting to note that in 1927 the spreading mechanization of Belgian factories prompted the creation of a new governing window-glass organization, the Comptoir General Belge pour la Vente des Verres Mecanique Fourcault.[64] This combination resembled its predecessors and also the then active foreign plate-glass combination, except that it lacked the international coöperation characteristic of the latter.

The years after 1920 are rich in data concerning the costs of producing window glass in the United States and Belgium, the principal competing country.[65] The topic consumed much space

[62] *Cylinder, Crown and Sheet Glass, 1930,* pp. 14, 16; "Window Glass Tariff Hearings," *American Glass Review,* XLVII (September 27, 1928), 15; "Window Glass Industry Prepares for Hearing on Production Costs," *American Glass Review,* XLVII (July 14, 1928), 27.

[63] *National Glass Budget,* September 7, 1918, p. 1.

[64] "The Belgian Glass Industry," *American Glass Review,* XLVII (November 26, 1927), 27; *American Glass Review,* October 6, 1928, p. 27.

[65] "Increase in Tariff Duties Asked," *Glassworker,* XL (January 15, 1921), 1; "Window Glass Tariff Brief," *National Glass Budget,* XXXVI (April 30, 1921), 1; "Data on Glass Wages," *Glassworker,* XL (July 2, 1921), 1; "Head of Window Glass Workers Calls for Tariff Action," *Glassworker,* XLI (Janu-

in the trade journals of the day and, presumably, not a little of the time of the United States Tariff Commission staff. The Tariff Commission conducted and completed two separate investigations of the cost of producing window glass in the two countries.

Domestic window-glass manufacturers began to complain of their competitive difficulties soon after World War I had terminated; continued agitation precipitated the first of the Tariff Commission inquiries. The Commission's research and the testimony taken apparently convinced its members that the existing high tariff on common window glass was insufficient to offset the cost disadvantage of a fully mechanized domestic window-glass industry, for it recommended an increase in rates of 50 per cent.[66] The President's proclamation making this recommendation effective became operative on June 13, 1929.[67] Only thirteen months after the President's proclamation the Tariff Commission instituted another investigation into domestic and foreign window-glass costs. This time it found that the existing cost relationships necessitated a reduction of 25 per cent in the ruling tariffs and subsequently such a change was made.[68]

Confronted by the results of the two investigations by the Tariff Commission, it is difficult to come to any conclusion other than that American cost of window-glass manufacture was greater than foreign (Belgian) cost after 1920. That the cost difference was sufficiently great to justify the tariff increases recommended, however, seems scarcely believable. It also appears remarkable that in the United States raw material cost

ary 3, 1922), 9; "Makers of Window Glass Seek Higher Tariff," *National Glass Budget,* XLII (April 23, 1927), 1; "Window Glass Industry Prepares for Hearing on Production Costs," *American Glass Review,* XLVII (July 14, 1928), 27; "Window Glass Tariff Hearing," *American Glass Review,* XLVII (September 15, 1928), 25; "Brief of Domestic Manufacturers in Window Glass Tariff Inquiry," *American Glass Review,* XLVIII (October 20, 1928), 17; "Tariff Commission Soon To Take Final Action in Window Glass Cost Inquiry," *American Glass Review,* XLVIII (January 12, 1929), 23; "Flat Glass Tariff Rates Discussed," *American Glass Review,* XLVIII (January 19, 1929), 23.

[66] *Cylinder, Crown and Sheet Glass, 1930,* p. 6.

[67] *Cylinder, Crown and Sheet Glass, 1930,* pp. 23–24.

[68] One member of the Tariff Commission advocated a reduction of the tariff by more than 25 per cent (*Cylinder, Crown and Sheet Glass, 1930,* pp. 4, 23–24).

should have been more than twice as great as in Belgium, repair and maintenance expense almost two and one-half times higher, general plant and office overhead more than two and one-half times higher, and imputed interest over three times the Belgian charges. These, however, are some of the discrepancies reported by the Tariff Commission.[69]

The contention that American window-glass costs were higher than foreign seems to be confirmed by the trend of American exports after 1920. Table 4 in the Appendix demonstrates the rapid and unrelieved decline of foreign sales of domestic window glass in this period. It should be noted, nevertheless, that this circumstance could have come about through foreign discriminatory price practices as well as by actual cost differences. It is, moreover, not improbable that such activities occurred.

In summary, we may conclude that protection to the American window-glass industry from 1890 to 1920 had no clearly beneficial consequences indisputably attributable to it. Up to 1903 the tariff facilitated and promoted prices substantially higher than cost and thereby delivered to both labor and employers varying degrees of monopolistic gains. In the era of mechanical improvement beginning in 1903–04 both costs and prices fell sharply, and, furthermore, tended to come together. Consequently tariff protection in the period 1903–1920 was less costly than ever before. The renewed attempts at combination after 1909 necessitate qualification of this statement, but it is nevertheless generally true for the period as a whole. The history of the years during and immediately after World War I constitutes, of course, an extraordinary and temporary episode quite distinct from the path of development before 1914.

It may be said further that the mechanical revolution cannot properly be accredited to the beneficence of a protective tariff. Since the middle of the nineteenth century, minds of inventive genius in many countries had been grappling with the broad problems of mechanized window-glass production. That successful mechanical production came first in the United States and came when it did can be attributed to the rising competitive dangers of cheap plate glass (of which more will be said later),

[69] *Cylinder, Crown and Sheet Glass, 1930,* pp. 18–19.

to the increasing burdensomeness of the restrictive practices of labor, to the mounting instability and uncertainty of production and marketing conditions, and to the apparently timeless desire for individual pecuniary achievement.[70] Although it is true that certain of these forces themselves were indirect resultants of a policy of high tariff protection, and that upon this basis it might be contended that the protective tariff was partially responsible for the coming of the mechanical revolution, the foregoing conclusion would not be weakened. It need only be pointed out: first, that there is no reason to suppose mechanical revolution would not have occurred without the presence of such accelerating forces (though not necessarily at the same time); second, that indirect beneficence of this nature could never have been envisaged by those responsible for formulation of a protective policy; and, third, even if so sophisticated an argument were admitted to be valid, final judgment upon the ultimate and net effect of such tariff protection would necessarily involve a balancing of economic gain against economic loss.

Since it is generally agreed by all sources that almost the entire quantity of window-glass imports after 1920 was consumed at or near the coastal entry points of the United States, and since it appears that foreign (Belgian) window glass would not have been able to penetrate into the great interior markets of the country except under most unusual circumstances, it seems just to conclude that the major consequence of the protective tariffs imposed on window glass after 1920 was retention to domestic producers of a greater portion of the eastern and western seaboard market areas than they would otherwise have been able to control.[71] This action, of course, placed a burden upon consumers of window glass so located. The wisdom of such support to American manufacturers can only be appraised in terms of debits and credits to general national welfare. Furthermore, it seems probable that the tariff increases made by presidential proclamation at the end of the period were greater than they needed to have been, if, indeed, they were necessary at all.

[70] Morton, pp. 40–41. *National Glass Budget*, January 19, 1901, p. 1; December 9, 1899, p. 1; "Wages and Machinery," XIX (May 23, 1903), 1.

[71] *Cylinder, Crown and Sheet Glass, 1930*, pp. 14–16.

CHAPTER IX

MECHANICAL REVOLUTION: THE GLASS CONTAINER INDUSTRY

Machine Manufacture

Successful machine bottle manufacture was not based upon a mere mechanized copying of manual bottle blowing. This method of solution, though obvious, was impracticable; in hand bottlemaking the bottle was first blown and then finished, or furnished with a neck and mouth, and to have duplicated this order in machine production would have created problems of extreme complexity. A radical and eventually successful step was taken in the introduction of the "blank" system, which divided the making of the bottle into two new operations and thereby broke down the difficulties to be overcome. By its use gathering the hot metal from the furnace became separated from the process of pressing and blowing. Moreover, the concept of the combined process of pressing and blowing further isolated technical difficulties and provided a means whereby the order of process of hand manufacture could be effectively reversed: mechanical invention first solved the problem of forming the bottle and then the problem of gathering.[1] We therefore find the first period of mechanical bottle manufacture an era of semiautomatic machinery for which gathering was done by hand.

Pressing constituted one of the two underlying principles of all semiautomatic bottle machines and it seems not unlikely that the remarkable progress which had been made in the pressed-glass industry of the United States exerted a direct influence upon the evolution of the ingenious press and blow combination. These two conjoined steps were first commercially utilized for the production of large pieces of tableware. In 1865 Gillinder patented a process for the making of glass

[1] "Automatic Bottle Manufacture," *Glass Industry*, II (March, 1921), 55.

pitchers by first pressing and then blowing; in this case, however, the blowing was not done in a mold and served merely to hold the article distended while it was shaped by tools. In 1873 Atterbury patented a process for united pressing and blowing; the lump of glass being pressed to form the top of the article and the "blank" then being expanded by blowing to the shape of the mold. Gillinder's machine had slight commercial use, and Atterbury's apparently none at all. In 1881 Phillip Arbogast patented a combined pressing and blowing device which first pressed the top of the object, then, after the article was removed to a blowing mold, expanded it to the shape of the mold by mechanically applied air pressure. The Arbogast machine was employed by D. C. Ripley of Pittsburgh for the manufacture of tableware and large containers such as druggists' jars, but it too was largely disregarded at first.[2] In 1886 the first machine for the manufacture of narrow-mouth bottles was designed and built by an Englishman, A. M. Ashley.[3]

Despite these early accomplishments, up to about 1892 practically all of the bottles manufactured in the United States were made by hand; the introduction of machinery had not received serious consideration.[4] In 1893 the Enterprise Glass Company secured the right to use the Arbogast machine and commenced mechanical manufacture of vaseline jars. Licenses were issued to several other manufacturers and considerable quantities of "packers goods" were made, that is, jars and wide-mouth bottles for liquids and pastes. Improvements were made on the original machines, the most important innovation being the development of a combined pressing and blowing mold which made unnecessary the transference of the article from the press to the blow mold. Furthermore, several other machines were introduced. By 1896 the improved machines were in successful operation at the Atlas Glass Works, Washington, Pennsylvania.[5] In 1898 the

[2] Barnett, pp. 67–68.

[3] "A Historical Note on the Ashley Bottle Machine," *National Glass Budget,* XXXIX (March 1, 1924), 1.

[4] "Introduction of Automatic Glass Working Machinery," *National Glass Budget,* XLII (July 17, 1926), 1.

[5] Barnett, p. 68.

Proeger machine was patented.[6] This device, which claimed successful manufacture of narrow- as well as wide-mouth jars, was not a pressing machine, working instead by suction and blowing. Still other new machines were introduced about this time. In 1898 the Ball Brothers, the largest manufacturers of fruit jars in the country, installed bottlemaking machinery.[7] Machine production hereafter became more and more widespread.

All the machines successfully introduced up to 1903 were devoted to the manufacture of wide-mouth ware and required the services of skilled workmen.[8] The degree of skill required, however, was much reduced.[9] The gatherer no longer gathered glass on a pipe but on a solid iron rod or pontil. Furthermore, he was no longer required to exercise as much care in the quantity of glass gathered. The quantity needed was determined by the presser who filled the mold by shearing glass off the pontil as the gatherer held it over the opening of the blank mold. The presser than turned his table one notch by means of a foot treadle and caused a descending plunger to shape the neck of the bottle and introduce the initial small cavity in the hot glass. After the next turn of the pressing table the partly formed bottle was removed and placed in the blow mold by the operator of the second, or blowing, table. This operator in turn rotated his table one notch, brought the mold under the blowing valve, released the compressed air and thus blew the "parison," or partly formed bottle, into the exact shape of the pattern in the mold. At the next turn of the blowing table a "take-out" boy removed the completed bottle, examined and weighed it, and placed it on a stand from which the "carrying-in" boy took it to the annealing lehr. The total number of workers on a three-man semiautomatic machine was five, three skilled workers and two helpers. The principal difference between the hand and the three-man semiautomatic method therefore lay not so much in

[6] "More Glass Working Machinery," *National Glass Budget,* XIV (December 17, 1898), 1.

[7] Barnett, pp. 68–69.

[8] *National Glass Budget,* July 17, 1926, p. 1.

[9] *Productivity of Labor,* pp. 32–34.

the number of workers displaced, only two helpers being eliminated, but rather in the lower grade of skill required.[10]

The next step in the process of mechanical improvement, the two-man machine, dispensed with the services of one skilled worker by supplying mechanical arrangements which permitted the gatherer and presser to do all the work of pressing and blowing.[11]

In 1903 the Owens bottle machine was first placed in commercial production. This mechanism was the work of Michael J. Owens, one of the greatest inventive minds in the history of the glass industry. Although the logical extension of the semi-automatic machine, it represented one of the most far-reaching improvements found in any craft.[12] The machine consisted of a number of working units, each complete in itself, mounted on a circular and continuously rotating framework.[13] Every unit completed a bottle during each revolution. Each unit, or arm, carried a vertical "blank" mold placed directly under and accurately fitted to a "neck" mold. These two molds were bored to hold the precise amount of glass required to make the bottle. The neck mold was exactly the shape of the neck of the bottle, while the blank mold was nearly cylindrical in shape and was designed to hold the entire amount of glass which was necessary for the part of the bottle below the neck. As the machine rotated, each unit carried its neck mold and attached blank mold over a revolving pot of molten glass. This pot was built into a combustion chamber adjacent to the refining tank, to which it was connected by a trough, the glass constantly flowing from the tank to the revolving pot. Special heating devices kept the glass in the pot at the temperature needed for the weight and size of the bottle. As each unit passed over the revolving pot it was lowered so that the bottom of the blank mold became immersed in the molten glass. At this moment the air was exhausted from the bored opening in the neck and blank molds, resulting in an im-

[10] *Productivity of Labor*, pp. 33–35.

[11] *Productivity of Labor*, pp. 34–35.

[12] Barnett, p. 86; "Important Developments in the Glass Industry," *National Glass Budget*, XLIII (May 7, 1927), 8.

[13] This sketch of the operation of the Owens machine is from *Productivity of Labor*, pp. 36–38.

mediate filling of the molds with hot glass, the lower part cylindrical and solid, the upper part in the shape of a neck of a bottle. As the molds rose from contact with the molten glass, a chisel-shaped knife swept across the bottom of the blank mold and cut off the string of glass that hung on the mold. Air was next admitted to the top of the neck mold to solidify the imprisoned glass and to enlarge the opening in the top of the neck of the partly formed bottle. Soon the two halves of the blank mold opened and the glass parison appeared, suspended by the neck portion enclosed in the neck mold. The finished mold rose from below. Once in proper position, it closed around the suspended parison and, by air forced through the opening in the neck mold, the glass blank distended to the pattern of the finishing mold. The bottle, now completed, fell out as the mold opened onto a rotating table or into the receptacle of the Owens conveyer.

The first Owens machine possessed six arms, or separate working units, but in the improvements which followed this number was greatly increased. With the utilization of the Owens automatic conveyer (an innovation following closely upon the perfection of the machine itself) bottle production became completely automatic. From the tank, through the machine, and through the lehr no worker handled the product. The average-sized Owens machine required one operator, either a machinist or foreman; if a machinist, two machines were tended by the same man.

For a number of years after its introduction the Owens was the only automatic machine extensively used in bottle production. Meanwhile the semiautomatic machines were improved and became more widely accepted. Most of the modifications were directed to the elimination of labor, both skilled and unskilled. With the use of electric power the two tables of the semiautomatic were made to rotate automatically in synchronization with the other operations of the machine. Next a cutting-off device was perfected which eliminated the presser and turned the two-man machine into a one-man machine. Then the transfer boy gave way to an automatic transfer and the take-out boy to an automatic take-out. These changes transformed the semi-

automatic machines into automatics so far as the blowing of the bottle was concerned. Well-known machines belonging to this period were the O'Neill machine, the Miller, and the Lynch, which was marketed as the "no-boy" machine.[14] Two other commercial varieties, the "Jersey Devil" and the United, English, or "Johnny Bull," introduced after and in 1904 respectively, were much-used representatives of the earlier class of semiautomatics.[15] The fundamental difference between the improved semiautomatics and the Owens machine was the semiautomatics' use of a gatherer to gather and feed glass. The usual attendants on the one-man machine were one gatherer (later three for two machines as working speed was increased) and one or more carrying-in boys, unless an automatic conveyer of the Owens type was employed. To these few surviving members of the old bottle-blowing shop were added one machine operator who watched the machine, regulated its speed, and changed molds, and a machine foreman in charge of several machines.[16]

But the days of the machine gatherer, the last symbol of what bottlemaking had been in the past, were numbered also. Even before 1900 some effort had been devoted to the solution of the problem of automatic feeding. Between 1900 and 1914 more vigorous attempts were made, but progress was slow and therefore only a small portion of the bottles made in the United States before 1917 were gathered on "feed and flow" devices.[17] After 1914, however, came a deluge of patents for feeders. Such renewed interest was attributed to widespread acceptance of the semiautomatics, the development of the "no-boy" machine (itself a consequence of the increasing scarcity of boy labor) which emphasized the presence of the single remaining hand factor in machine bottle production, and to the fact that the semiautomatics had developed a rate of speed all but impossible for an individual gatherer, or even two gatherers, to maintain. In consequence of the increasing number of commercially effective

[14] *Productivity of Labor,* pp. 34–35.

[15] *Productivity of Labor,* p. 32.

[16] *Productivity of Labor,* p. 35.

[17] "Automatic Glass Feeding Devices," *Journal of the Society of Glass Technology,* I (1921), 134.

1920 is well summarized in the following description of the Libbey-Owens plant at Charleston.[21] The buildings of the factory were carefully designed to provide maximum light and ventilation and were constructed throughout of fireproof material. At all pertinent locations temperature control and recording instruments were installed. The raw materials of the batch were delivered by mechanical power shovels and scrapers onto continuous belts and into buckets emptying into cylindrical concrete tanks. The ingredients passed from the tanks — being automatically weighed in transit — to a revolving drum resting upon a motor rail car, which transported the batch to storage bins suspended at the charging end of the tank furnace. From the bins the ingredients were fed to the fire at prescribed intervals. On delivery from the Owens blowing machine, the bottles dropped upon perforated metal pans which in their forward movement were synchronized with the speed of the machine. Resting on the pans the completed bottles were carried first to and then through the annealing lehr; they were then inspected and packed, and finally, by similar automatic means, were transported to the storage bins or shipping cars. This plant, representing a capital investment of $3,000,000, operated twenty-four hours a day, six days a week. Though all bottle factories had not attained equal perfection of process, it is nevertheless generally true that the technique of American bottle manufacture in 1920 bore little resemblance to the practice of 1890.

In the period 1920 to 1929 the development of American container manufacture followed paths already clearly defined in 1920. The industry as a whole became more and more completely dominated by automatic bottle manufacture. In the course of this process the commercial importance of the feed and flow devices mounted steadily and, correspondingly, the relative quantitative significance of the Owens invention declined.[22] Improvement of the bottle machines themselves was non-revolutionary and, for the layman, difficult to discern; tech-

[21] "Bottle Making at Owens Charleston Plant," *Glassworker,* XXXIX (June 6, 1920), 18; "Survey of the Glass Industry," *National Glass Budget,* XXXV (January 10, 1920), 1.

[22] *National Glass Budget,* July 17, 1926, p. 1.

nical progress after 1920 was the result of a long series of small, unspectacular innovations, unimportant individually, and not departing radically from the general principles of the great inventions of the years 1890 to 1920.[23] With continued betterment of forming-machine equipment went improvement in the preliminary and finishing phases of bottlemaking. In tank construction, composition and mixing of clays, feeding and firing, mechanical mold production, annealing and conveying, the bottle and other branches of the glass industry progressed after 1920.[24] Large-scale operation and efficient factory organization became factors of increasing significance.

The total number of machines in operation rose steadily and rapidly after 1897, and the semiautomatic machines decreased after 1917 in consequence of the success of the feeding systems (see Table 17). Despite continuous increase in the number of Owens machines, their rate of increase was less precipitous than might have been anticipated from the revolutionary character of the invention. Two factors account for this: the high installation cost of the Owens machine and the restrictive policy pursued in the disposition of rights to its use. After 1917, with the rapid adoption of the perfected automatic feeders, the proportion of total output made on the Owens bottle machine declined. In 1918 over 10,000,000 gross bottles were made on the Owens and only about 500,000 on gob feeders. By 1925 the Owens was responsible for roughly 12,500,000 gross and the feeders for somewhat over 8,500,000.[25]

In 1905, notwithstanding the fact that a large quantity of wide-mouth ware was then produced on the semiautomatics, by far the greater part of total bottle production was carried on in hand plants.[26] By 1917 a radical change had occurred; 50 per cent of total output was machine made. By 1922–23 the use

[23] *National Glass Budget,* May 7, 1927, p. 8.

[24] "Bottle Molds Produced by Automatic Machinery," *Glassworker,* XXXIX (July 10, 1920), 38; *National Glass Budget,* May 7, 1927, p. 8; "Glass Industry Meets with Many Obstacles in 1927," *National Glass Budget,* XLIII (December 31, 1927), 1; "Twenty Years of Glass Making," *Glass Industry,* XII (July 1931), 141.

[25] *National Glass Budget,* July 17, 1926, p. 1.

[26] *National Glass Budget,* July 17, 1926, p. 1.

TABLE 17

MECHANIZATION OF THE AMERICAN CONTAINER INDUSTRY, 1897–1929

Year	Machines All Types	Semiautomatic Machines: Wide mouth	Semiautomatic Machines: Narrow mouth	Semiautomatic Machines: Total	Owens Machines
1897	20	..	..	20	..
1898	50	..	..	50	..
1899	60	..	..	60	..
1900	80	..	..	80	..
1901	90	..	..	90	..
1902	100	..	..	100	..
1903	150	..	..	150	..
1904	200	..	..	200	..
1905	250	..	..	250	..
1906	176[a]	168	..	168[a]	8
1907	209[a]	191	..	191[a]	18
1908	257[a]	223	..	223[a]	34
1909	270[a]	205	19	224[a]	46
1910	277[a]	216	..	216[a]	61
1911	328[a]	173	52	225[a]	103
1912	390[a]	170	96	266[a]	124
1913	449[a]	201	96	297[a]	152
1914	476[a]	210	102	312[a]	164
1915	634[a]	193	265	458[a]	176
1916	646	167	292	459	187
1917	628	..	..	428	200
1918	..	..	..	417	..
1919	..	..	..	..	..
1920	..	..	..	315	..
1921	..	..	..	288	..
1922	..	..	..	164	..
1923	..	..	..	130	..
1924	..	..	..	72	..
1925[d]	..	..	..	98[c]	..
1926	..	..	..	..	..
1927	..	..	..	26[c]	..
1928	..	..	..	..	..
1929	1,109[b]	..	..	0[c]	..

Data from Barnett, except as noted. Data not available for all unfilled entries.

[a] Number not complete, includes only semiautomatic machines under jurisdiction of the union.

[b] Data from Census of Manufactures, 1925, 1929; for the pressed and blown industry as a whole not merely for bottles and jars

[c] Data from Jerome, p 425 Jerome's data from Glass Bottle Blowers' Association.

[d] In 1925 the total number of arms or stations for all machines was 2716 and in 1929 there were

of feeders had raised this figure to 80 per cent and in 1924–25 to 90 per cent.[27]

Labor Organization

It will be remembered that in 1890 the production of bottles and containers was dominated on the side of labor by two strong unions, the Green Glass Bottle Blowers' Association and the American Flint Glass Workers' Union. Both of these organizations, by virtue of their influence in the employer-union conference system, exercised discretion over working rules, length of the summer stop, wages, and apprenticeship. The introduction and relentless growth of machine production after 1890 precipitated conflict between the two unions, forced them to formulate new policies and readjust old, and ultimately modified their power.[28]

The logical division between the bottle workers belonging to the Green Glass Blowers and those belonging to the Flint Glass Workers turned upon the process of production, green, or common, glass being melted in open pots and the finer flint glass in closed pots. This line of demarcation, however, disappeared with the introduction of tank furnaces since both flint and common glass could be successfully made in them. Because the price list (or piece wages) for the blowing of green bottles was less than that for flint bottles as the tank furnace became more commonly employed, bottle production formerly held by the Flints was gradually transferred to factories controlled by the Green Glass Blowers. This seed of fraternal discord was fertilized by the introduction of the semiautomatic bottle machines.

At the time of the first experiments in machine-produced packers ware the Flints, who had jurisdiction over the pioneer machine plants, decreed that the output of the machines should be limited to a stated move, since the machine process involved pressing and the pressing department of the Flints had a "move list," although their prescription bottle department did not. This ruling caused the machines to be transferred to certain nonunion

[27] Barnett, p. 85.

[28] A large portion of this section, the labor history of the bottle industry from 1890 to 1920, is from Barnett, pp. 65–115.

factories. In 1896 the Flints made a price list for semiautomatic production but apparently few union workers were employed on the machines until 1898. In that year semiautomatics were introduced into the Ball Brothers factory, controlled by the Green Glass Blowers. At their 1898 conference the Blowers agreed to work the machines and persuaded the Ball Brothers management to allow some of their members to transfer their tasks. The employers, however, desired to make use of skilled pressers and as a result members of both unions operated the machines. This incident was the beginning of a long conflict between the Flints and the Green Glass Blowers for control of machine production. The Flints contended for it on the basis of having control over pressing, and the Blowers on the plea that the machine made bottles and displaced blowers. In 1900 the Flint prescription-bottle department went over to the Glass Bottle Blowers (as the Green Glass Blowers were called thereafter) and by 1905 the conflict was decided in the Bottle Blowers' favor. A jurisdictional agreement between the two unions was consummated in 1913.

The early machine policy of the Glass Bottle Blowers was devoted to securing machine-operator positions for displaced blowers; in this endeavor the union had moderate success. The workers were fortunate too that neither wages nor hours of work were adversely affected in the early years of semiautomatic bottlemaking machines. Although union policy contributed to this, a fundamental cause lay in the concomitant rapidly increasing demand for glass bottles. Table 18, displaying the course of green-glass blowers' wages from 1890 to 1907, indicates rising time rates and slightly falling hours of labor in the later portion of this period.

In 1907, when the Owens machine became an important competitive factor in bottle production in the United States, nearly nine-tenths of the hand blowers and operators of semiautomatic machines were union members. There were a few nonunion plants and a few semiautomatic machine factories under control of the Flint Glass Workers' Union but neither were important. Furthermore, throughout the period 1907–1917 the Glass Bottle Blowers increased its domination over both classes of workers.

The events of the years between 1903 and 1909 compelled a reformulation of union policies. This interval witnessed the improvement of semiautomatic machines, the introduction of semiautomatics for the manufacture of narrow-mouth bottles (in 1907), and the appearance and growing competitive power of the Owens invention. To meet these new and dangerous conditions the Glass Bottle Blowers decided to pursue new tactics: introduction of the three-shift system; reduction in the number

TABLE 18

WAGES OF GREEN-GLASS BLOWERS IN THE NORTH ATLANTIC STATES, 1890–1907

Year	Hours per week	Wages per hour	Year	Hours per week	Wages per hour
1890	52.7	$.511	1899	50.8	$.538
1891	51.7	.499	1900	51.0	.593
1892	52.1	.538	1901	51.0	.633
1893	52.8	.503	1902	51.0	.597
1894	51.8	.507	1903	51.0	.605
1895	51.6	.495	1904	51.1	.710
1896	51.7	.502	1905	50.9	.672
1897	51.8	.486	1906	47.9	.762
1898	52.7	.478	1907	47.8	.796

Data from *History of Wages in the United States*, p. 234.

of apprentices; encouragement of the semiautomatic machines; and reduction in the piece price of bottles made by hand.

The two-shift system, a practice of long standing, gave way to the three-shift system in 1912 in the hand plants and a year earlier in semiautomatic factories; employment of blowers was thereby stimulated. The traditional limitation of apprentices to one for every fifteen journeymen was maintained until 1913. The union then made a radical change in its rules in order to remove the source of profit it believed employers had discovered in employing relatively large numbers of lower paid apprentices. The length of the training period was reduced and the approved apprentice wages increased by 50 per cent. The favorable attitude of the Glass Bottle Blowers toward the semiautomatic

machines had its genesis in the desire of the union to assist these machines in the struggle against the Owens automatic. Though the semiautomatics themselves caused displacement of blowers, the adoption of the Owens machine led to the prospect of no employment of skilled glassworkers whatever. The union also took advantage of the introduction of the two-man and one-man semiautomatic machines to secure higher piece rates on machine work. The final tenet of the new union policy, reduction of piece rates in hand factories, was an obvious short-term defensive measure. In 1909 a 20 per cent reduction became effective on certain ware then being made on the Owens machine, which was gradually but progressively being adapted to new types of bottle production. In 1912 a further 20 per cent reduction was granted on all Owens ware, and two years later another 20 per cent cut became applicable to the small bottles that the Owens machine was by that time producing successfully. In consequence of higher piece rates on machine ware and the reductions in the rates on hand ware, the wages of hand and machine workers became equal in 1914 and machine wages greater than hand wages by 1917.

Between 1907 and 1917 hand blowers' wages fell from an average of about $7.00 a day to about $6.00. Since wages in other trades were meanwhile rising by nearly 30 per cent, the decline in comparative wages was considerably greater.[29] Since machine operators' wages were higher than hand workers' wages after 1917, the trend of wages was relatively more favorable to the machine workers. More significant than the trend of wages, however, was the fact that not less than half the hand blowers working in 1907 had by 1917 been forced out of their craft and into relatively unskilled occupations. In 1917 the competitive pressure of the Owens bottle machine finally compelled the workers to abandon the traditional summer stop. For this concession compulsory vacations were substituted, but continuous operation had nevertheless been granted to the manufacturers.

The troubles of the union were not yet terminated. Successful introduction of the feed and flow inventions presented, from

[29] Barnett, pp. 104–105.

the union's point of view, another discouragingly difficult problem for solution. The automatic feeders were first installed in nonunion factories and it thus became necessary for the Bottle Blowers' Association to organize these plants and to negotiate with a new set of employers. This it consistently attempted to do after 1918. Effort was directed to placement of the newly unemployed machine operators on the automatics. In 1924 it was estimated that about one-third of the 2000 machine operators working in 1917 had secured such positions. In process of this change, however, wages were reduced almost to the level of unskilled labor. The negotiated agreements of 1918 called for payment of $.50 an hour. Efforts of the union later resulted in slight increases above this low point; in 1919 the rate of $.60 was established, in 1920 the rate of $.66, and after 1922 the rate of $.60. The continuous improvement of the Owens and the new automatic machines also reacted adversely on the wages and employment of the remaining hand blowers. Displacement continued and relative wages again fell. In 1924 the money wages of hand workers were said to have been $7.00 a day, $1.00 more than in 1917, but meanwhile other union wages had risen by 80 per cent.[30] Hand blowers in 1924, as today, had but one field left to them, the manufacture of oddly shaped and oddly sized bottles, usually made in closed-pot furnaces, with distinctive decorative features, and supplied in comparatively small quantities.

Throughout the mechanization of the American bottle industry the Glass Bottle Blowers' Association remained what it had been in 1890 in form only. Beneath the surface much was changed. The range and extent of the union's power had been severely curtailed, the wages of most of its members had been reduced nearly to the level of unskilled labor (only 749 of the more highly paid hand blowers were reported in union factories in 1924),[31] and continuous weekly and yearly operation had been conceded. The power and glory of 1890 had been relentlessly swept away.

[30] Barnett, pp. 112–114.

[31] Barnett, p. 114.

Increased Productivity

Table 19 presents a statistical history of the American bottle and container industry from 1899 to 1929 and shows the vast increase in both value and quantity of product.[32] Quantity of output in 1919 was almost three times that of 1899. The three great periods of augmented production, 1899–1904, 1904–1919, and 1919–1929, correspond with the widening influence of the semi-automatic machines, the growing importance of the Owens invention, and the perfection of automatic feeding machines. The rates of increase computed are not directly comparable since the first applies to a five-year interval, the second to one of fifteen years, and the third to one of ten years. They nevertheless sharply delineate the extent of the growth in the industry's productiveness. The coincidence of a declining number of establishments and tremendously increased output reflects the fact that machine production divested the American container industry of its long-maintained small-scale, low-capital investment (and, incidentally, migrant) characteristics. The effects of machine production on costs are evident in the comparison of average unit values with the Bureau of Labor Statistics index of wholesale prices. Finally, the table points to near exclusion of foreign bottles from the domestic market.

Tariff Protection

The tariff act of 1890 made no important change in the duties imposed upon imported bottles. Under the act of 1883 a \$.01 per pound specific duty had been levied upon all empty containers. This specific duty was now modified and graduated according to capacity. Bottles over one pint — green, colored, molded, or pressed, flint or lime — were taxed at the old rate of \$.01 per pound, those above one-quarter pint capacity at \$.015 per pound, and all below this limit at \$.50 a gross. The short-lived act of 1894 reduced these three rates to \$.0075, \$.01125, and \$.40. The act of 1897 restored the duties of 1890 but provided

[32] The production figures for 1890 employed in Chapter VII have not been included in Table 19 since they are not strictly comparable to the subsequent data.

TABLE 19

Total Production, Average Unit Values, and Imports of Containers, 1899–1929

Year	Total Production[a]: Number of establishments	Total Production[a]: Value (thousand dollars)	Total Production[a]: Quantity (thousand gross)	Total Production[a]: Increase in quantity (per cent)	Index of average unit values[b] (per cent)	Bureau of Labor Statistics wholesale price index (per cent)	Total imports of empty containers (thousand dollars)	Domestic production as percentage of imports plus domestic production
1899	147	21,677	7,780	..	100.0	100.0	150	99.31
1904	158	33,631	12,005	54	100.0	109.8	280	96.17
1909	166	36,018	12,316	..	105.0	124.6	210	99.42
1914	150	51,959	19,290	..	96.4	128.7	220	99.58
1919	145	94,670	22,295	86	152.3	273.4	10	99.89
1921	..[c]	85,743	..[c]	..	..	188.2	60	99.93
1923	117	107,231	28,393	..	135.5	188.7	..[g]	..[h]
1 25	120	100,301	26,044	..	138.0	203.3	..	..
1927	..[d]	114,381[e]	30,660[e]	..	134.1	..[f]	..	.
1929	..	121,654	35,686	58	122.7	..	..	..

Data from *Productivity of Labor in the Glass Industry* and Census of Manufactures for the years specified; import data from *Commerce and Navigation* for the years specified.

[a] Items included: beers, sodas, minerals, liquors, flasks, beverage containers, prescription ware, vials, druggists' ware, patent and proprietary ware, medicinal and toilet preparation containers, milk jars, fruit jars, packers' and preserve ware, packers' ware (wide and narrow mouth), demijohns, carboys, general purpose containers, and all other bottles and jars.

[b] Index of average unit values on 1899 base.

[c] Not reported.

[d] The number of establishments reported by the Census of Manufactures 1927–1929 are not subject to the classification employed in *Productivity of Labor in the Glass Industry* and hence have been omitted.

[e] The manner of reporting quantity and value of product was changed in 1927 and there is therefore a possibility that the figures for 1927 and 1929 are not strictly comparable to the earlier years, but there is no official warning of such discrepancy.

[f] The wholesale price index is one recomputed by the compilers of *Productivity of Labor in the Glass Industry* and hence cannot be continued.

[g] The series of total imports of empty containers cannot be derived after 1921.

[h] This series cannot be continued because import figures are not available.

that no bottles should come in at less than 40 per cent ad valorem. The act of 1909 made no change in the bottle glass schedule but the 1913 act abolished specific duties and substituted for them ad valorem rates of 30 and 45 per cent.[33] The 30 per cent rate was applicable to pressed or mold-blown bottles and in effect was more important than the 40 per cent.

The averages of the ad valorem equivalents reported by the tables of *Commerce and Navigation* for the period 1890–1913 approximated, for bottles and demijohns over one pint, 50 per cent, for bottles over one-quarter of a pint, 70 per cent, and for those below the quarter-pint limit, 60 per cent.[34] The protection afforded the American bottle industry between 1890 and 1913 in so far as empty container imports were concerned ranged from about 50 to approximately 70 per cent. After 1913 the tariff advantage amounted to 30 and 45 per cent.

The duties on bottles imported filled were, with a few minor exceptions, identical under all the tariff acts enacted up to 1920. Such containers were dutiable at the same rates as those imported unfilled. The acts of 1890, 1897, and 1909 provided, however, that bottles containing substances dutiable at an ad valorem rate should themselves be taxed at those rates, but no filled bottles were permitted entry at less than 40 per cent.

Under the acts of 1890, 1894, 1897, 1909, and 1913, bottles and other articles cut, engraved, or otherwise decorated paid respectively 60, 40, 60, 60, and 45 per cent. The tariff act of 1922 abolished the bottle duties of 1913 and restored the rates of 1909. Dependent on size, foreign containers were taxed at \$.01 and \$.015 a pound and \$.50 a gross through 1929.[35]

[33] *Tariff Acts,* pp. 369, 465, 545, 700; *Comparison of Tariff Acts,* p. 26.

[34] Data from *Commerce and Navigation,* 1890–1913.

[35] *Comparison of Tariff Acts,* pp. 26–27. The series entitled Value of Total Imports of Bottles and Other Containers, to be found in Table 7 in the Appendix, reports as accurately as possible the value of all types of containers imported. Because of the manner of recording employed in the tables of *Commerce and Navigation,* it is impossible to include the value of cut, engraved, or otherwise decorated bottles except for the years 1895–1897, when they were separately reported. The series also omits the large quantity of bottles imported filled whose value was not reported. Despite its defects this series appears to constitute the closest possible approach to a complete statement of combined plain and decorated bottle imports. More significant are imports of empty bottles. Filled bottles and containers come into a country not because that

For the American glass container industry the period 1890–1929 constituted an era of mechanical revolution. In 1890 only hand factories were in existence and the total product of that year was attributable to them. By 1905, despite the fact that a wide variety of wide-mouth ware was then being made by semiautomatic machine, by far the largest portion of domestic production still came from the hands of skilled craftsmen. After the advent of the Owens invention both the proportion of bottles made by machine and by completely automatic devices rose significantly. The widespread introduction of mechanical feeders after 1917 further accelerated this transition. Fifty per cent of the bottles and containers produced in 1917 were made by machine and 80 per cent by 1922–23. At the end of the period under consideration the once dominant and powerful hand industry had been reduced to the confines of a narrow and unimportant field. There is much truth in the statement that the factory typical of the 1920's looked more like a machine shop than a bottle works.

In the process of forty years of industrial metamorphosis the costs of American bottle production fell sharply. The Bureau of Labor Statistics estimated in 1927 that the average decrease in the direct labor cost of making fifteen different types of bottles (ranging in size from one-half ounce to five gallons) by use of the semiautomatics was 59 per cent and by use of the automatics 94 per cent.[36] Though these percentages of course do not coincide with net decline in cost (because of the greater capital equipment employed in mechanical production, and other factors) they nevertheless afford a clear indication of the magnitude of the changes involved. The value and price indices of

country desires bottles but because it desires their contents. Hence, empty bottles constitute the class of imports pertinent to an examination of the competitive position of the domestic bottle industry. It is for this reason that the annual values of unfilled bottle imports have been employed in computing the percentages of Table 19.

In Chapter VII computation of the percentages of total consumption supplied by domestic production was based upon an approximation of total value of bottle imports. The method outlined above was not utilized because statistics of bottles imported empty do not become available in the tables of *Commerce and Navigation* until 1884.

[36] *Productivity of Labor,* p. 54.

Table 19 reveal that, relatively, average bottle values in 1919 were 44 per cent lower than in 1899; the comparable relative fall by 1925 was approximately 32 per cent.

Such profound alteration of costs exerted a definite influence upon the competitive position of the American industry. In general it may be said that competitive competence became increasingly favorable after 1890. As early as 1900 it was contended that the United States led the world in fruit-jar production.[37] Two years later this statement was broadened to include all machine-made jars.[38] In 1903 it was reported that the jar and bottle branch of the glass industry would soon have to find a foreign market and that formerly the American industry had been confined to supplying the domestic demand in consequence of high wages and more costly methods of production.[39] In 1912 America was characterized as in the foreground of glass-producing nations in the bottle and jar industry.[40] Even domestic hand bottle methods were described as in advance of Europe in 1918; productive technology was said to be superior and worker productivity greater.[41] In 1922 it was admitted without qualification that American processes of bottlemaking were nearer perfection than in any other country of the world.[42]

The most conclusive evidence of the competitive ability of American bottle producers appears in the data of exports (see Appendix, Table 8). Foreign sale of bottles and other containers was not separately reported until 1914. In that year domestic bottle exports amounted to over $700,000. Thereafter the totals rose steadily until 1920. For our purposes, however, the figures of the period following World War I are the important ones, for it was then that a true test of competitive strength was undergone. The fact of continuous export of about or over $3,000,000 annually (up to 1929) justifies the contention that America had

[37] "The Art of Glass," *National Glass Budget,* XVI (November 10, 1900), 1.

[38] "Progressive Steps in Glass Making," *Commoner and Glassworker,* XXIV (November 29, 1902), 14.

[39] *National Glass Budget,* May 30, 1903, p. 1.

[40] "Wherein We Are Deficient," *National Glass Budget,* XXVIII (September 28, 1912), 1.

[41] "Moderate Tariff Advocated," *National Glass Budget,* XXXIV (September 21, 1918), 1.

[42] "Tariff Protection Needed," *Glassworker,* XLI (August 26, 1922), 12.

achieved a state of competitive advantage in this branch of the glass industry.

Throughout the period 1890–1929 imports of foreign bottles, specifically those imported empty, were subject to heavy protective duties. What can be said of the consequences of this policy? By virtue of a protective tariff and the incidental protection arising from the transportation and breakage costs attendant upon foreign importation, American bottle producers had in 1890 already achieved near monopoly of the domestic market. This position of strength was maintained and even increased during the following forty years. The explanation of control during the period 1890–1920 was, however, different from that which pertains to the years preceding 1890. Before 1890 conquest and retention of the domestic market was dependent largely upon the operation of a protective tariff and after the first years of the twentieth century, upon low-cost production. It follows, therefore, that the protective tariff on glass containers during the first quarter of the twentieth century was largely superfluous. In the same degree that American bottle costs were lowered, and at the rate of their decline, the tariff became unnecessary. Exception should be made of that portion of the hand bottle industry still clinging to its ancient traditions in 1929. Even here, however, wages had been reduced (at least relatively), technique bettered, and productivity increased. The change from a high-cost handicraft to an exporting machine industry entailed no sacrifice to bottle and container consumers; they benefited markedly from the technological revolution.

Rather than upon tariff protection the advent of mechanical revolution in American container manufacture appears to have rested fundamentally upon the requirements and prerequisites of the general evolutionary process of mechanical invention. As in the case of the window-glass industry, it is not to be doubted that the support to high wages afforded the glass blowers through the instrumentality of the tariff hastened the search for and development of mechanical invention. In this sense it is true that the tariff promoted far-reaching industrial change, but such course of beneficence was, to say the least, far different from that anticipated by traditional protectionists.

CHAPTER X

MECHANICAL REVOLUTION: THE PRESSED AND BLOWN GLASS INDUSTRIES

THE BRANCHES of the American glass industry not embraced by the window-glass, plate-glass, and bottle and container industries are many and heterogeneous, but almost all the various articles produced by these branches fall into the pressed and blown — or to use the old term, the flint and lime — categories. The major items included in this discussion are pressed ware; blown ware including chimneys, electric light bulbs, other illuminating equipment, and tableware; chemical ware (primarily imports); and specialties of all sorts.[1]

PRESSING MACHINERY

The development of machinery for making pressed glassware in the period after 1890 was much slower and less striking than in the container and window-glass industries. For this there are several explanations.[2] In the first place, the pressed glass process of 1890 was already partially a mechanical one, comparable to the stage of progress attained in the container industry with the introduction of the semiautomatic machines. Another cause lay in the multiplicity of products classified in this branch of the glass industry. Literally thousands of individually shaped articles were produced by pressing and, with the exception of tumblers, were made in relatively small quantities. Furthermore, when semiautomatic and automatic machinery was

[1] Analysis of the data of imports and domestic production is restricted to consideration of the items mentioned above; types of glass manufacture of an essentially secondary nature will not be discussed, nor will the status of optical glass and glassware be considered, for data relating to this particular sub-industry has been consistently eliminated from the statistics of imports and domestic production.

[2] *Productivity of Labor,* p. 88.

introduced, hand press manufacturers were not forced either to install the new devices or to withdraw from business, as had the bottle producers; the pressed-glass manufacturers had a third alternative — to discontinue the article taken over by the machines and divert their attention and labor force to a field not yet so affected. Neither the need nor the use of machinery was as compelling as in container and window-glass manufacture.

It will be recalled that the hand-operated side-lever press and the shop consisting of a gatherer, a presser, a finisher, and two or more helpers, were the characteristic features of pressed-glass production in 1890. The transition from what was incorrectly called the hand method to the semiautomatic stage of manufacture did not constitute such a radical change as the corresponding transition in bottlemaking.[3] In the latter case the semiautomatics displaced the finisher and gradually replaced the blower by a semiskilled machine operator. No comparable event transpired in pressed glassware; the transition was so gradual and the effects on the industry so slight that, were it not for the increase in worker productivity, no distinction could be drawn between the two stages. The principal differences in the processes were the number of molds employed and the kind of power used to operate the plunger. Even these two changes were not brought about simultaneously. Many side-lever presses had already been worked with two or more molds when the rotary press was introduced.

The rotary glass press consisted merely of a rotating table equipped with four to six molds and surmounted by a plunger operated in the early years by compressed air and later by electric power. This use of mechanical innovation did not directly modify either the composition of the shop (the working unit) or the essential method of production. The output of the shop was considerably increased, however, and the work of the presser lightened. An indirect result of the greater productivity of the machine press was the gradual replacement of the "warming-in" or reheating boys and of the hand finisher by glazing or finishing machines. The first machine for finishing tableware

[3] The following sketch of the "mechanization" of the pressed-glass industry has been taken from *Productivity of Labor,* pp. 88–93.

was introduced commercially in 1886; in the early years of the twentieth century several different types were in use.[4] Some were longitudinal, in the form of a belt conveyer, but most were circular. The latter consisted of a revolving table rimmed with a series of spindles or cups which held the articles to be finished. Part of the circular path of the machine was hooded and fitted with gas jets. These threw their flame upon the glass objects as they passed beneath them. While moving around the axis of the machine each spindle rotated rapidly, thus exposing to the flame every part of the glass surface requiring finishing. By this process the edges of the article were melted, smoothed, and polished in one revolution of the machine. Two boys, a "sticking-up" boy who placed the article on the spindle and a "take-out" boy, were required to tend it. The "carry-over" boy, the "warming-in" boy, and the finisher were thus displaced by two unskilled boys who could finish all the ware made upon either the semiautomatic or automatic machine.

Something approaching revolutionary change came in pressed-glass manufacture with successful introduction of automatic feeders in 1917. As in bottlemaking the gatherer was completely eliminated and the work of the presser became so simplified as to amount merely to tending, thus allowing replacement of the presser by a semiskilled machine operator. As the speed of the machine was increased, the removal of the ware from the molds was relegated to a take-out boy. In the case of finished ware the take-out boy transferred the article to a tray from which it was taken to the lehr by the carrying-in boy. In the case of unfinished ware the take-out boy placed the object on a stand where it could be reached by the glazing boy. In certain plants the glazing machine was placed so that the "taking-out" and "sticking-up" were done by the same worker. When glazed, the ware was placed on the tray belonging to the carrying-in boy. But if an automatic conveyer were used and placed close to the glazing machine, the carrying-in boy was also eliminated, leaving but one worker necessary to the final processes of pressed-ware production.

[4] "The Machine Question," *National Glass Budget,* XIV (March 4, 1899), 1.

All of the several types of automatic presses introduced were similar mechanically and none were as large or as complicated as the automatic bottle machines. An automatic press consisted of a round table equipped with from six to eight molds and surmounted by a power-driven plunger. The table rotated intermittently, its motion being synchronized with that of the feeder and the plunger. The feeder discharged the gob of glass just at the moment that the mold took its place under the feeder and as the table moved one notch the plunger dropped into the mold and performed its task of pressing. Pressing and finishing thus became entirely automatic and the only attendants necessary were the machine supervisors and a take-out boy. The final step in elimination of labor was achieved when an automatic take-out was perfected.

Products made by the automatic pressing machines included tumblers of all shapes and sizes, nappies, bowls, trays, and a considerable amount of small stemware such as sherbet and sundae glasses. As has already been suggested, the hand plants confined themselves to a multiplicity of specialized products manufactured in small quantities; they therefore did not compete with machine factories. The situation was somewhat similar to the case of hand bottle plants making specialized containers for toilet preparations and perfumes, but with the difference that toilet and perfume bottles represented but a small fraction of the bottles made, while pressed "novelties" constituted a very large part of total output, representing in 1927 nearly one-half the total.

Blown Glassware Machinery

The development of machinery in the blown-ware division of the glass industry was more pronounced than in pressed glass, for in this field the higher wages and continuously maintained power of skilled craftsmanship offered strong incentives for the introduction of mechanized process. After 1890 repeated effort was made to eliminate hand production of many different types of blown glassware. Not all were successful; in 1920 and 1929 a substantial number of products were still a function of the art

of the glass blower. In certain lines, however, there were revolutionary triumphs, notably in the manufacture of lamp chimneys, electric light bulbs, punch tumblers, and glass tubing.[5]

Glass chimneys originally and for many years were blown off-hand. The operation was performed by a three-worker shop composed of a gatherer, a blower, and a crimper. The first two workers were skilled and the last semiskilled. Before the introduction of the crimping machine the entire process was carried through by skilled workers. The chimney was blown and shaped by typical off-hand blowing methods. In preliminary forming the chimney remained closed at both ends. One of these the blower opened, trimmed, and shaped to fit the lamp holder. The top of the chimney was smoothed, formed, and after being reheated crimped by a crimping machine, which was simply a circular crimped mold with an interior revolving cone.[6]

A second method of chimney manufacture was known as the paste-mold process, so called because of the coating placed on the walls of the mold in which the chimney was blown.[7] The technique was like any other mold-blowing operation except for the use of paste and the rotation of the pipe while the product was being blown. These processes were necessary to prevent seams or other impressions which a dry mold would have left on the glass. After annealing, the chimneys passed through glazing and crimping operations both of which, after the invention of the crimping and glazing devices, were performed by machines tended by nonskilled labor.

The semiautomatic lamp chimney machine was the invention of M. J. Owens and first became commercially successful in 1898. Subsequently it underwent modification and improvement and other inventors contributed new types.[8] In the stage of per-

[5] The following description of processes, except where otherwise noted, is from *Productivity of Labor,* pp. 110–136.

[6] For a good many years the best grade of lamp chimney was blown off-hand ("The History of Glass Making: Illuminating Glass," *Glass Container,* VI [June 1927], 11).

[7] Previous to the introduction of the paste-mold process, lamp chimneys had been produced in wooden molds; the paste mold was an improvement on the latter (*The Glass Industry,* 1917, p. 18).

[8] *National Glass Budget,* XIV (March 11, 1899), 1; "The Lamp Chimney Combine," *National Glass Budget,* XV (June 17, 1899), 1.

fection which had been achieved by 1927 the mechanism consisted of a rotary table equipped with five paste molds which opened and closed automatically. The initial stages of gathering and blocking were identical with the hand paste-mold process. When the chimney was ready to be blown, the glass globe, attached to the pipe, was placed in the paste mold of the machine. This closed around the glass and held it while compressed air introduced into the blowpipe formed the chimney. During the blowing process the chimney rotated rapidly on its own axis. At a certain point on its journey around the table the mold opened automatically, released the pipe and chimney to the cracking-off boy who separated the two. After being annealed, the chimney, as in the hand processes, was glazed and crimped. Like the hand paste-mold method, two or more chimneys could be blown at once. It was later found more practicable, however, to blow one chimney at a time, but with its lower end lengthened and so shaped as to make a salable tumbler when cut off from the chimney. Cutting the tumbler from the lower end of the chimney was done by a special cracking-off apparatus. When separated the tumbler had to be ground, glazed, and washed.

The Owens chimney machine and possibly others of its type were also extensively used for the manufacture of thin blown tumblers and similar ware.[9]

The first glass bulbs for incandescent lamps were made by manipulating tubing over a flame.[10] This practice was followed until electric light bulbs began to assume commercial importance and a cheaper method of bulb production became highly desirable. The first attempts to make bulbs on a blowpipe apparently took place at Corning, New York, in the late 1870's. After laborious experimentation a successful off-hand process was developed and made possible a product which was a distinct improvement over the bulb previously used. The bulbs thus made were more uniform in shape and size, were satisfactory in uniformity of thickness, and possessed the physical properties

[9] Walbridge, p. 55; "Owens' Blowing Machine," *National Glass Budget*, XIII (October 23, 1897), 1.

[10] The following treatment of bulb manufacture is in part from *The Glass Industry, 1917*, pp. 17–20, and in part from *Productivity of Labor*, pp. 117–125.

necessary to effective use. With the perfection of machines for holding and manipulating lamps in process of final manufacture, greater accuracy in the forming of the bulb became imperative. This situation was met by substituting the wooden-mold process for the off-hand method. The wooden mold had long been used in the production of globes, chimneys, and similar articles, and why it had not been originally adopted for the making of bulbs is not known. The new process was virtually identical with the manufacture of glass chimneys by the paste-mold process. The method utilized a hardwood water-soaked mold and the familiar technique of simultaneous turning and blowing. The product was much more uniform in size and shape, possessed a high polish as a result of the rotary motion of the glass while in contact with the mold, and could be made faster and more cheaply than previously.

With the elaboration of machinery for lampmaking, glass bulb requirements became more and more exacting. It became necessary to find a mold material more reliable than wood; wooden molds burned or warped out of shape and sometimes produced imperfect products. Glass manufacturers accordingly began to utilize the paste-mold process. A cast-iron mold was coated with a mixture of linseed oil and charcoal or hardwood sawdust and heated to induce carbonization of the paste. Before each blowing the mold was immersed in water, for otherwise the blank could not be rotated in the mold nor could a high polish be obtained.

As in the container industry, machinery first invaded bulb manufacture through the medium of semiautomatic processes. The semiautomatic bulb blower consisted of a long water-filled base over which were four or five operating units, each equipped with a paste mold, an arm to hold and to operate the blowpipe, and a piston through which compressed air entered the blowpipe. In the process of manufacture the gatherer withdrew an iron blowpipe from the "blow-iron trap" and gathered glass exactly as in the hand shop, except for the fact that the glass was not marvered as formerly. The pipe with the attached blank was then locked in the machine, which was set in motion. The blowpipe, rotating rapidly, rose to contact a metallic marver

which marvered the glass in a single revolution. Air then entered the blowpipe and the blank assumed a pear-shaped form. The machine next stopped temporarily while the blank became further elongated and descended between the two halves of the paste mold, which meanwhile had risen from the water below. Finally, the machine was once again set in operation and the bulb blown by compressed air. When it reached its final form, the bulb, still attached to the blowpipe, tipped out into the waiting hands of the take-out boy, who turned it over to the cracking-off boy. After it was disengaged from the pipe, the bulb was completed and required only inspection and packing. The use of the semiautomatic machine displaced the blower, lightened the work of the gatherer, and made necessary the services of a take-out, a cracking-off, and a section boy. Though the number of workers needed on the machine was larger than in hand production, the average output was three times greater and the man-hour output also considerably higher than in the hand method.

By 1927 two completely automatic bulb-blowing machines had been developed, the Empire and the Westlake. The Empire "F" machine when operated in connection with an automatic feeder constituted a complete automatic unit. Though capable of producing any paste-mold ware of limited size it was used originally for the manufacture of electric light bulbs. The machine employed two intermittently rotating tables, each supplied with six blowing units. Each unit was made up of a blank-forming press, a blowing spindle, and a blow mold. Gobs of glass were fed alternately to each blank-forming press down an inclined trough which oscillated between the two tables, loading them alternately. The blank was pressed in the spindle, a cup-like device, reheated and rotated, elongated by its own weight, enclosed in a paste mold, rotated again, and finally blown to the shape of the blowing mold. When finished the bulb ejected itself automatically, to be picked up by the automatic conveyer and carried to a burning-off machine. This mechanism cut off the superfluous holding collar and fire polished the rough edges. The product was then ready for packing. All movements of the Empire machine were entirely mechanical and completely synchronized.

The Westlake blower was built upon a large rotating drum from which twelve blowing units were suspended. Each of these units carried two spindles of blowing pipes, a ram with two pipes for gathering glass, a mechanism for admitting air into the blowpipes, two paste molds, and a series of cams and wheels to synchronize the operations of the various parts. The rams, automatically projected into the furnace opening, made two gathers at once. By a vacuum process the gathers were sucked into blank molds, from which they dropped onto the blowing spindles. The transfer of the glass from one mold to another cooled the gather sufficiently to obviate marvering. When the jaws of the spindle had closed on the glass, a plunger automatically indented the gather and the resulting depression was blown out by intermittent puffs of compressed air. The spindle was again rotated, then inverted. The glass gob was elongated by its own weight and the compressed air, and was blown out into a paste mold which rose to enclose the partially distended bulb. Upon release from the machine the product fell upon an automatic conveyer which took it via an automatic loading apparatus to a "burning-off" or finishing machine. From the latter the cut and polished bulb was pushed out upon another automatic conveyer, carried through a short annealing lehr, out upon another automatic conveyer and thence to the inspection and packing stations. It was here that the bulb, for the first time, was touched by human hands. A machine operator and sometimes an attendant on the burning machine constituted the sum total of necessary direct labor. Both workers needed no preparatory skill and learned their work in a comparatively short time. Later improvements on the first type of the Westlake machine resulted in better quality of product, greater uniformity, and faster production.

At an early date the Westlake blowing apparatus was utilized in the manufacture of other blown ware, particularly punch tumblers.[11] The process was identical with that for the blowing of electric light bulbs except for the difference in mold equipment and finishing devices.

In one other subbranch of the blown-ware industry, the production of glass tubing, mechanical invention wrought moment-

[11] *Productivity of Labor,* p. 134.

ous change. The process of making tubing by hand utilized the services of four skilled and four unskilled or semiskilled helpers.[12] The skilled workers were the "gaffer" or blower, the marverer, the ball maker, and the gatherer. The assistants included a "carry-over" boy, a "punty" boy, a "drawing" boy, and a "cutting" boy. The drawing process was begun by gathering, marvering, and regathering between thirty and forty pounds of glass on a blowpipe. The ball of glass was then attached to an iron rod having a large iron disk on one end. The gaffer and the punty boy, one holding the blowpipe and the other the "punty" or pontil, walked slowly away from each other, the gaffer meanwhile blowing into the plastic mass. When the drawing and blowing were completed, the cutting boy divided the usable part of the tubing into desired lengths. It has been estimated, however, that by the hand method not much more than 25 per cent of the total length of tubing drawn was salable.

The Danner apparatus for the manufacture of glass tubing, introduced in 1917, was more a process than a single piece of machinery. By this method molten glass had to be transferred from the melting to a drawing furnace, the principal element in the Danner technique. The drawing furnace possessed two chambers arranged so that the glass flowed from the first to the second by gravity. Within the second chamber was located an iron blowpipe, one end of which connected with an air tank outside the furnace; the other end protruded from the front opening of the furnace. The iron pipe or "mandrel" was kept in constant rotation and by its motion gathered glass into a cylindrical formation. The admission of air changed this formation from cylindrical to tubular. The drawing apparatus proper was located some distance from the furnace. It consisted of two endless chains one above and one below the tube, running on sprocket wheels. These chains were equipped with gripping pads and rollers which held the tubing and exerted the pulling force. In passing from the furnace to the drawing machine the glass tubing was supported by a trough containing a series of pulleys. Upon leaving the drawing machine the tubing moved

[12] Data concerning glass-tube manufacture are from *Productivity of Labor*, pp. 137–148.

over a short table, the end of which was pressed upward by a spring. By means of such pressure the tubing at certain intervals met a cutting wheel which cut the glass into the lengths desired. The cut pieces slid off the cutting table to an attached platform from which they were removed by an attendant or by the drawing-machine operator.

With the exception of the ladling of the glass from the pot to the drawing furnace, the Danner process required no skill or physical labor of any kind; only machine supervision was necessary. Furthermore, the tubing produced by machine was far superior to and more uniform than the hand-produced tubing. The Danner invention proved so superior to hand methods that in 1926 it was reported that not a single plant in the United States could be found making tubing in the old manner.

The product classification by which the Census of Manufactures for 1899 to 1929 reports domestic production in the American pressed, blown, and other glassware industry comprises the following major divisions: tableware; jellies, tumblers, and goblets; lamps; chimneys; lantern globes; globes, shades, and other gas and electric goods (including electric light bulbs over a portion of the interval 1899–1929); blown tumblers, stemware, and other bar goods; glass tubing; and all other pressed and blown ware. To the last category certain separately reported product classes may, for consistency, be added.[13]

In 1890 none of the products falling within the above classifications were manufactured by machine, unless the hand press be so described. By 1920, however, at least the major portion of pressed and blown output emanated from mechanized factories. Because of the complexity of the items and the multiplicity of their number, no precise statement of the proportion made by machine and by hand can be formulated. It is definitely established, however, that semiautomatic and fully automatic devices were producing over half the pressed ware output in 1927.[14] The remainder came from hand presses, improved but still operated

[13] The term "pressed and blown industry" is employed in this chapter as coextensive with the production of all glass and glassware other than plate, window, bottles, and containers. For emphasis, the term "pressed, blown and other" has been used above.

[14] *Productivity of Labor*, p. 89.

in the manner of 1890. The range of pressed-glass products was, as it always had been in the United States, very wide. It included a large quantity of tableware, standard types of jelly glasses, tumblers, probably goblets, and other articles.[15] These types were made primarily by machine. The hand press industry, while it also made goods of such general classification, predominated in the field occupied by small-lot production, by novelties, and by innumerable specialties. Such essential difference of markets caused these sister branches of the glass industry to become only distantly competitive, and permitted the vigorous survival of the older hand methods. An immense variety of products was made by hand pressing. Some of the most important classes included tableware of all sorts, specialties, globes, shades, and other lighting ware.

Not all tableware was made by pressing, however. Hand-blown tableware plants continued to exist, making in general finer grades of product. Quantities of standardized blown goods were also produced by such blowing machines as were adaptable to these purposes, the Westlake, for example.[16]

After 1898 an increasing number of glass chimneys were produced by semiautomatic processes. In that year the American Lamp Chimney Company was formed.[17] This concern bought the patent rights of the Owens chimney machine and at its inception anticipated control of one-half of total domestic consumption. Shortly afterwards a further concentration of chimney production was effected by the formation of the Macbeth-Evans Company which in turn absorbed, among others, the newly constituted American Chimney Company.[18]

Despite the early introduction of machinery in the chimney industry, its conquest over hand production was neither rapid nor complete. As late as 1927 it was estimated that from 40 to 50 per cent of the chimney output was still made by the off-hand process. The principal cause of this peculiar situation lay in the declining state of the chimney market as a whole.

[15] *Productivity of Labor,* p. 93.

[16] *Productivity of Labor,* p. 134.

[17] "Chimney Blowing Machine," *National Glass Budget,* XIII (April 16, 1898), 6.

[18] *Glass Container,* June 1927, p. 11.

The manufacturers were fully aware of the condition and accordingly refused to make the large outlay necessary to the introduction of machinery. Survival of the off-hand chimney process has been further explained on the ground of superiority of product. In 1927 the lamp chimney industry was described as "probably the only field in the glass industry where hand manufacturing not only has survived the introduction of machinery, but actually manages to subsist side by side with the machine." [19]

The fate of the craftsmen in the electric bulb sub-industry was in sharp contrast to the fate of the chimney blowers. The situation in 1920 in this branch of the glass industry is epitomized by the report of one of the most important electric light bulb producers in the country. This concern revealed that in its plants slightly less than 40 per cent of total output was produced by hand, slightly more than 60 per cent by semiautomatic machine, and a fraction of 1 per cent by automatic machine.[20] By 1927, however, the automatic process had come into its own; both the hand and semiautomatic methods had been almost completely displaced, for more than 95 per cent of total production came from two different but entirely automatic processes.

The foregoing pages demonstrate that in the forty years subsequent to 1890 those major and minor branches of the American glass industry other than the window, plate, and container branches, were, like the latter group, revolutionized by mechanical invention. No progressive chronological estimate of the proportion of output in these fields produced by semiautomatic and automatic methods is available. It is certain, however, that the importance of the hand worker in the pressed, blown, and other branches of the American glass industry had been heavily reduced by 1920, and still more so by 1929. It should also be noted that here, as in the branches of the glass industry previously discussed, a large number of ancillary improvements were introduced in the non-forming phases of glass production after 1890.[21] These related to mixing and feeding of materials,

[19] *Productivity of Labor,* p. 114.

[20] *Productivity of Labor,* p. 126.

[21] "Pittsburgh and the Glass Industry," *American Glass Review,* XLVI (March 26, 1927), 15.

furnace construction, melting, annealing, finishing, conveying, and handling. All contributed to improvement of competitive position.

The Chemistry of Glass

One of the most notable characteristics of the American glass industry after 1920, and one which had peculiar relevance to pressed and blown production, was the increased interest in and practical application of the chemistry of glass. America had been particularly deficient in this respect prior to World War I. In 1902 there were said to be but seven chemists in the entire American glass industry.[22] The development of automatic forming machinery called for greater emphasis upon scientific glassmaking, but despite this technical fact no great advance had been made up to 1914. By 1929, however, really significant progress had occurred. Practically all glass manufacturers employed chemists, or, if they did not employ them continuously, retained them in a consultative capacity.[23] In consequence, it was claimed, America led the world in the application of chemical and other scientific principles to glassmaking.[24] The effect of this evolution upon the pressed and blown branches of glass manufacture is seen in the development, in the period after 1920, of various types of low-expansion glasses, colored glasses for railroad and highway signal work, lead-free glass used in machine-produced electric bulbs, silica-free glass for the transmission of ultra-violet light, Crooks glass for spectacle lenses, welders' glasses, heat-intercepting structural glass, and numerous kinds of optical, scientific, and other special-purpose glass and glassware.[25]

Labor

Despite widespread and far-reaching mechanization, the craftsmen specializing in the manufacture of pressed and blown

[22] "Chemistry in Glass Manufacturing," *American Glass Review,* LIII (September 29, 1934), 13.

[23] "A Note on the Development of the Glass Industry," *Glass Container,* I (November 1921), 8.

[24] *American Glass Review,* September 29, 1934, p. 13.

[25] "Development in Glass Technology During Past Quarter Century," *American Glass Review,* XLVI (May 28, 1927), 15.

glass products fared better than those in the window-glass and glass container branches of the industry. This condition rested upon the importance in this field of special products, small-lot output, and variation in quality and design. Had it not been for these factors the magnitude of displacement of labor would have been comparable to that which took place in container manufacture. Since an official statement of the changes in occupation forced upon the members of the American Flint Glass Workers' Union appears to be unavailable, it is necessary to estimate the extent of displacement that occurred. It seems probable that by 1920 nearly one-half of the pressed-glass workers, about 60 per cent of the electric light bulb blowers, a considerable number of glass-tube artisans, somewhat less than half of the chimney blowers, and a significant portion of blown tableware craftsmen had been compelled to alter their trade. Some no doubt shifted to other branches of the glass industry and to the machines. Others moved out of their chosen craft altogether. In any event, it is clear that mechanization of the pressed and blown glass industries necessitated substantial reduction in the ranks of the skilled workers formerly employed.

Though precise statement again is not to be found, it is equally clear that mechanization of the pressed and blown glass industries must have had a generally adverse effect upon the wages of members of the American Flint Glass Workers' Union. Exception would, of course, have to be made in those cases where specialization in conjunction with variability and small quantity of production made the application of machinery impracticable. A study issued by the Bureau of Labor Statistics indicates that in 1917 average hourly wages in tableware production were higher than in the production of lighting goods and lamp chimneys, substantially greater than in bottle and jar production, but lower than the payment made to window-glass workers. The revived activity of the hand window-glass plants, a response to the temporary demand conditions of the World War I period, accounts for the superior wage conditions of the window-glass workers.[26] These relationships are, in general, those which would have been anticipated from knowledge of the gen-

[26] *The Glass Industry, 1917*, pp. 246–249, 293.

eral history of the pressed and blown industry between 1890 and 1920. With regard to specific wages one reasonably accurate comparison may be made. In 1899 flint-glass blowers received an average wage of $.505 and $.562 per hour in the North Atlantic and North Central districts.[27] In 1917 average hourly wages of tableware blowers and lighting goods and lamp-chimney blowers were $.70 and $.5461, respectively.[28] Money wages in the tableware department thus had increased by 31 per cent, as compared with the average of the two 1899 rates, and in the lighting goods department by 3 per cent. The index of wholesale prices employed by the Bureau of Labor Statistics for comparisons of price movements in the glass industry was 173 per cent higher in 1919 than in 1899.[29] Despite the facts that the dates are not exactly comparable and the wage data also are not exactly comparable, a very sharp fall in real wages is evident, being more precipitous in the branch where machinery had made the deepest inroads.

A further effect of the introduction of machinery in the pressed and blown branches of the glass industry, at least in certain of the departments, was the abolition of the limited move system.[30] This is said to have been true of pressed-glass manufacture in which actual output in 1927 averaged 15 to 20 per cent above the previously effective stated limit.[31] As in the container industry, mechanization also weakened and largely eliminated the traditional practice of the summer stop. In 1917 it was reported that most departments of the pressed and blown industry operated continuously throughout twelve months with no shutdowns except for two weeks in the summer and on certain holidays.[32]

[27] *History of Wages in the United States,* p. 234.

[28] *The Glass Industry, 1917,* p. 249.

[29] *Productivity of Labor,* p. 19.

[30] *The Glass Industry, 1917,* p. 313.

[31] *Productivity of Labor,* p. 100. The statement of this usually dependable authority seems open to question in regard to pressed ware. Other authorities have repeatedly stated that unlimited production was introduced in pressing as a result of the great struggle between the United Glass Company and the American Flint Glass Workers' Union in the years immediately following 1893. See, for example, *Regulation and Restriction,* pp. 657–658.

[32] *The Glass Industry, 1917,* p. 314.

Improvement of Competitive Position

Mechanization of the pressed and blown glass industries substantially improved the competitive position of domestic producers. In the manufacture of pressed jars, however, the United States in 1890 already held a position of advantage, and therefore installation of mechanical equipment in this field merely heightened an existing superiority. Quite the contrary held true of practically all branches of the blown glass industry prior to mechanization. In these divisions high wages and limited output promoted high-cost production; only in the lamp chimney industry, which had developed most rapidly in this country, do domestic manufacturing expenses appear to have been less than foreign.[33]

Many comments upon the competitive position of the pressed and blown branches of the American glass industry are available for the period shortly before and shortly after 1900. In every case it is emphatically stated that in the rapid, cheap, and mechanical process of hand pressing no one excelled or even equaled American producers.[34] In 1899 it was reported that pressed tumblers, goblets, tableware, and novelties were being exported in an increasing ratio and that such exports had then passed the $1,000,000 mark.[35] In 1900 the total of pressed glass exports was set at $1,900,000. At this same time, with the exception of a few chimneys and the cheapest grade of machine-made lamps, domestic manufacturers exported practically nothing in the field of blown glassware.[36] Indeed, exports of glass of all other types were insignificant; total glass exports were $1,500,000 in 1899 and $1,940,000 in 1900.[37]

This same structure of competitive position prevailed from

[33] In 1899 it was said that American lamp chimney manufacturers were able to make the best and cheapest chimneys on earth and were likely to supply the markets of the world. The prediction was not fulfilled, however. (*National Glass Budget,* XV [May 27, 1899], 1; "American Glass Exports," *National Glass Budget,* XVII [July 20, 1901], 1.)

[34] *National Glass Budget,* XV (December 16, 1899), 1; "Progressive Steps of the Glass Industry," *National Glass Budget,* XVIII (November 1, 1902), 1.

[35] *National Glass Budget,* XIV (January 7, 1899), 1.

[36] *National Glass Budget,* July 20, 1901, p. 1.

[37] See Appendix, Table 2.

1900 to 1920 except in those branches revolutionized by mechanization. Little pressed glass was imported and a considerable amount exported. In 1917 not a single manufacturer interviewed by representatives of the Bureau of Labor Statistics complained of imports of pressed ware, but all engaged in the production of blown glass were concerned about imports of their product. The total pressed and blown imports in 1917 consisted in great part of classes of blown glassware not yet made by machine; these were in the majority of cases produced in small quantities, were of special design, and were the result of a large amount of hand labor. The groups included fine blown stemware; ornamented, etched, cut, or colored tumblers; plain goblets; and cheaply decorated blown ware.[38] In 1918 it was said that before World War I not more than one-half of the thin blown ware used in the United States was made here, and that during the war period American manufacturers did not attempt to take advantage of the respite from foreign competition because they felt confident of renewed competition after the war had terminated.[39] Furthermore, before 1914 a negligible part of chemical and scientific glassware used in this country was produced domestically, imports accounting for by far the largest portion. During the period of conflict this branch of domestic industry received much attention and attained considerable success.[40]

In those lines of pressed and blown flint and lime production profoundly altered by mechanization, America had by 1920 achieved a position of notable competitive strength. Some indication of the range of increased productivity and lowered cost can be derived from percentages of direct labor cost reduction. In comparison with hand pressing, the semiautomatic inventions effected an average direct labor cost reduction of 45 per cent on common tumblers, 27 per cent on sherbets, and 41 per cent on nappies. For these same articles the cost reductions resulting from completely automatic production were 91, 87, and 85

[38] *The Glass Industry, 1917,* p. 348. Pressed ware imports consisted largely of door knobs.

[39] "Table Glassware Industry," *National Glass Budget,* XXXIV (October 5, 1918), 4.

[40] *The Glass Industry, 1917,* p. 223.

TABLE 20

TOTAL PRODUCTION, AVERAGE UNIT VALUES, AND IMPORTS OF PRESSED AND BLOWN WARE, 1899–1929

Year	Total Production[a]				Index of average unit values[b] (per cent)	Bureau of Labor Statistics wholesale price index (per cent)	Total imports of pressed and blown ware[c] (thousand dollars)	Domestic production as percentage of imports plus domestic production
	Number of establishments	Value (thousand dollars)	Quantity (million pieces)	Increase in quantity (per cent)				
1899	84	17,076	360	..	100.0	100.0	1,280	93
1904	103	21,956	428	19	108.2	109.8	2,270	91
1909	114	27,398	532	24	108.6	124.6	1,890	93
1914	107	30,279	701	32	91.1	128.7	2,580	92
1919	130	70,749	1,080	54	138.1	273.4	840	99
1921	..[d]	55,718	..[d]	..	..	188.2	3,240	94
1923	127	77,279	..[d]	..	.	188.7	4,200	95
1925	123	72,086	1,963	82	77.4	203.3	4,120	94
1927	..[e]	80,260	..[f]	..[g]	..[g]	.[g]	6,700	92
1929	..	87,696	..	..	..	..	6,350	93

Data from *Productivity of Labor in the Glass Industry* and Census of Manufactures for the years specified

[a] Items included 1899–1925 are described in *Productivity of Labor in the Glass Industry* as pressed and blown ware, all items reported except window, plate, bottles and containers, and lenses included 1927–1929.

[b] Index of average unit values on 1899 base.

[c] Imports include all glass and glassware except beads, optical glassware of all types, plate and window glass, and bottles and containers.

[d] Not reported.

[e] The number of establishments reported by the Census of Manufactures after 1925 is not subject to the classification employed in *Productivity of Labor in the Glass Industry* and hence has been omitted.

[f] Quantity of product not derivable after 1925.

[g] Cannot be computed after 1925.

per cent, respectively. In lamp chimney manufacture the semiautomatic blowing machine brought a direct labor cost saving of 38 per cent over the off-hand process and a 16 per cent saving over the paste-mold process. The labor cost reductions in bulb manufacture were enormous; the semiautomatic machine produced twenty-five watt bulbs at 60 per cent less labor cost than hand production, while automatic machine production averaged a saving of about 96 per cent. In the manufacture of punch tumblers by the Westlake machine direct labor cost declined by 93 per cent and the Danner tube-drawing apparatus permitted a comparable saving of about 85 per cent in glass tubing production.[41]

Table 20 presents a statistical history of the pressed and blown branches of the glass industry from 1899 to 1929. The features of this table which should be especially noted are the steady and rapid growth in quantity of output, the declining trend of average unit values, the absence of any declining trend in value of imports, and the continuously large portion of domestic production plus imports attributable to domestic manufacture. It is particularly remarkable that the 1925 index of average unit values is far lower than the comparable indices in the window-glass and bottle industries, in which mechanization was more complete and equally revolutionary. Such a discrepancy strongly suggests some type of statistical distortion; it is probable that it is attributable to unwarranted and unintentional quantity weighting. This error, of course, does not vitiate the general evidence of sharply falling costs and prices.

In 1890 domestic production of flint and lime glass and glassware constituted 90 per cent of total consumption. In the years after 1899 there was an increased, if not increasing, domination of the domestic market by home industry. The gains, however, were nowhere near the proportions attained by American container production.

Tariff Protection

The degree of tariff protection bestowed upon the pressed and blown branches of the American glass industry between 1890

[41] *Productivity of Labor,* pp. 98–99, 114, 127, 135, 143.

and 1920 was heavier than ever before.[42] Under the act of 1883 the rates had been 40 and 45 per cent. The provisions of the act of 1890 imposed 60 per cent ad valorem duties on all but chemical ware which was charged at 45 per cent. The short-lived enactment of 1894 reduced these stipulations to a level of 40 per cent except for the 35 per cent duty applicable to non-specified glass and glassware. The tariff of 1897 restored 60 per cent impositions on all but non-specified glassware, which was dutiable at 45 per cent. The law of 1909 raised the already high level by requiring a generalized 60 per cent tariff with no exceptions appended.[43] It was not until the Democratic tariff of 1913 that the duties on flint and lime glassware were lowered.[44] That act provided for collection of 45 per cent ad valorem on all classes except non-specified articles and electric light bulbs and lamps, all of which paid 30 per cent. Since events of the years of World War I prevented operation of the tariff reductions of 1913, it may be said with close approximation to the truth that the pressed and blown branches of the glass industry enjoyed, for practically the entire period 1890–1920, a tariff advantage of 60 per cent.

The tariff act of 1922 abolished the pressed and blown glass duties established in 1913 and substituted far heavier impositions.[45] Scientific glassware, which under the act of 1913 paid 30 and 40 per cent, was made dutiable at 65 per cent; glass tubes, formerly charged at 30 and 45 per cent, were dutiable at 55 and 60 per cent.[46] The duties on illuminating glass were set at 60 and 55 per cent; in 1913 they had been 30 or 45 per cent. Table and kitchen ware was dutiable at 45 per cent in 1913 and at 55 per cent in 1922. Pressed goods paid 50 per cent under the revised tariff. Electric light bulbs, in contrast, were taxed at 30 per cent in 1913 but at 20 per cent in 1922. Glass and glassware not specified carried a rate of 30 per cent in 1913 and 50 per cent in 1922.

[42] Exemption should perhaps be made for the period 1842–1846.

[43] *Tariff Acts,* pp. 369, 465, 545, 700.

[44] *Comparison of Tariff Acts,* pp. 26–28.

[45] *Comparison of Tariff Acts,* pp. 27–31.

[46] Duties provided for manufactures of fused quartz have been consistently eliminated.

During the years between 1890 and 1920 the pressed and blown glass industries underwent notable improvement. Those subbranches which were deeply affected by semiautomatic and fully automatic mechanization experienced substantial betterment of competitive position. In consequence of the degree of machine invasion which had occurred by 1920 in chimney and electric light bulb manufacture and in certain phases of other fields of blown-glass production, it seems probable that in these branches America had achieved a cost status equal if not superior to other glassmaking countries. It is incontrovertibly established that this cost status existed in all types of pressed-glass production long before 1920.

The pertinent testimony of import and domestic production statistical comparison unfortunately cannot be presented because the abnormal conditions of the years of World War I render the import data devoid of significance. Furthermore, the Census of Manufactures for these years report, in the several individual classifications, figures for quantity but not for value of output. It may be noted, however, that even in 1904, before mechanization had made much progress, imports of glass and glassware other than plate, window, bottle, and optical totaled $2,270,000 and of this figure imports of cut, engraved, and otherwise decorated glassware and porcelain, opal, and other blown glassware (that is, imports embodying a great amount of hand labor) amounted to $1,762,000, or more than 75 per cent of the total.[47]

One may conclude that the tariff imposed on flint and lime glassware in 1920 and for a considerable number of years prior to that date was unnecessary for the continued existence and prosperity of a broad section of the pressed and blown glass industry in the United States. This allegation applies to the production of pressed glassware, glass tubing, and to the lamp

[47] *Commerce and Navigation,* 1904. See Appendix, Tables 11 and 12. The series of plain tableware exports in Table 12 indicates the superiority of the American pressed-ware industry; lighting equipment exports in part do also, though they likewise reflect the efficiency of domestic manufacture of electric light bulbs. The exports of cut and decorated glass (articles embodying much hand labor) reveal the relative disadvantage of American producers in the manufacture of this class of glassware.

chimney, tumbler (in part), and electric light divisions of the blown-glass industry. A contrary conclusion follows for those branches of the pressed and blown industry which in 1920 remained virtually unaffected by mechanization. In the maintenance of these fields of domestic glass production the tariff was imperatively necessary. It is a circumstance worthy of note that in the tariff hearings of 1909 and 1913 a major portion of the testimony was devoted to the representatives of just such branches of the American glass industry.[48] The continuing large importation of the type of articles made by the domestic hand glass branches is in itself some proof that even a 60 per cent tariff did not equalize domestic and foreign costs of production. Furthermore, it could well have been anticipated for the future that in the degree that mechanization of the hand glass industries was either impracticable or impossible, a similar if not equal competitive disability would persist. America had never been a cheap glass producer where human skill and human skill alone constituted the major factor in production.

The reaffirmation of heavy tariff protection to the flint and lime glass industries of the United States after 1920 had little or no effect upon the progress of mechanization. In those industrial branches that bettered their mechanical equipment subsequent to 1920 the paths of improvement had already been well defined and it is highly probable that the improvements would have been made regardless of the height of the tariff wall. After 1920, as before, the necessity for high protection, or for any protection at all, varied greatly among the several constituent branches of pressed and blown manufacture. There seems to be little doubt, for example, that the 50 per cent import duty on pressed glassware was largely superfluous; no evidence has been discovered to indicate that American pressed glass producers were troubled by foreign competition. The export data of Table 12 in the Appendix does not weaken this contention even though the course of exports of plain glassware seems to indicate a somewhat less favorable position of American producers in foreign markets; some reaction was to be expected upon post-war revival of European glass industries. It is

[48] *Tariff Hearings, 1909; Tariff Hearings, 1913.*

CHAPTER XI

MECHANICAL REVOLUTION: THE PLATE-GLASS INDUSTRY

THE HISTORY of plate-glass manufacture from 1890 to 1920 contrasts markedly with the chronicles of development in other branches of the American glass industry. Unlike the container, window, and pressed and blown industries, domestic plate-glass production underwent no fundamental change in technical methods, in the status of labor, or in general industrial and economic organization. Though the workers employed in 1920 performed operations differing from those of 1890 and though in consequence of the increasing use of mechanized devices manual skill was less significant than it was thirty years earlier, technical progress made necessary no radical labor readjustment nor did it precipitate any important amount of labor displacement. Indeed, the plate-glass industry as a whole was spared the difficulties and disturbances of fundamental transformation.

The evolution of plate-glass manufacture between 1890 and 1920 constitutes a progressive realization of the economic tendencies manifest in 1890, by which time American plate-glass production had already become a large-scale and partially mechanized process, far less dependent on skilled labor than most other branches of the glass industry. In the following three decades the degree of skill required by the workers was diminished, mechanization became more complete, and capital investment per establishment continued to rise. The improvements in the productive technology of plate-glass manufacture between 1890 and 1920 fell into two general classes, betterment of the casting and allied phases of plate-glass making and achievements in grinding and polishing.

Progress in Technology

Up to 1900 most if not all attempts at progress in the plate-glass industry, aside from some details in construction of machinery and a little improvement in the quality of the glass, had been directed to continuous increase in the size of the plates cast; methods of casting, annealing, grinding and polishing had remained virtually unchanged.[1] At the beginning of the twentieth century, however, two important innovations in the casting process were introduced. The first and most significant was the continuous annealing lehr, which consisted of five preliminary ovens and a runway some three hundred feet long. Its use permitted the entire process of annealing and cooling to be accomplished in three hours.[2] In contrast, the old methods of kiln annealing required the plates to be pushed into ovens which, because of their large preheated mass of brickwork, took forty-eight hours to cool. The continuous lehr was first perfected by the Marsh Plate Glass Company of Walton, Pennsylvania, but other manufacturers gradually adopted it. The lehr, moreover, had an influence beyond its own efficiency and economy; it affected the mechanical manipulation of casting the sheets, for through its use it became possible to keep the casting table stationary in front of the first oven. With the previously utilized rows of annealing kilns which were constructed to hold but one to three plates, it had been necessary to move the table from kiln to kiln so the glass sheets could be pushed into the proper receptacle for tempering.[3]

The second casting innovation occurring in the first years of the present century consisted of the introduction of large travel-

[1] "Development of Plate Glass," *Commoner and Glassworker,* XXII (March 2, 1901), 1.

[2] "Sheet and Plate Glass Industry Makes Rapid Progress," *American Glass Review,* XLVI (May 28, 1927), 17.

[3] "Progress Made in Plate Glass Manufacture," *Glass Industry,* II (January 1921), 3; *American Glass Review,* May 28, 1927, p. 17. It has been said that the lehr method of annealing plate glass was first and most fully developed in America and was not used in Europe until the years shortly preceding 1920 ("Historical Sketch of American Plate Glass Manufacture," *Glassworker,* XLII [April 7, 1923], 11).

ing power-driven cranes used in transporting the pots of molten glass from the furnace to the casting table.[4]

According to the methods of the older English grinding and polishing machines, the segments of plate glass, having been annealed and cut to eliminate the more obvious defects, were sent to the grinding department, laid in plaster of Paris upon square or octagonal tables and rotated under iron-shod runners. Downward filtration of sand, ranging from coarse to very fine, provided the medium for grinding. When a flat surface had been obtained the plates were turned over, reset, and the process repeated. The time required for grinding varied from eight to twelve hours. After completing this much of the finishing process the plates were removed, cleaned, and again imbedded in plaster of Paris and rubbed against one another over an emery friction material until a finely ground surface resulted. The plates were then transferred to the polishing department and placed once more upon tables. Felt-covered blocks descended on the glass and by use of rouge and the sliding motions of the machine the surfaces were given the characteristic high polish of plate glass. The completed plates were then sent to the warerooms to be examined for defects and cut into desired sizes.[5]

Important modifications were made in the above-described technique and equipment between 1890 and 1920. The first progressive step was taken about 1890 by the Crystal City plate-glass factory, which abandoned the English type of smoothers and ground and polished all glass on grinding machines. This change required alteration in the design of the mechanical apparatus, and circular working tables were substituted for the previously utilized square or octagonal type. The effect of this new method was to reduce the grinding and smoothing time by over 50 per cent.[6] It also led to a further improvement.

The table or deck on which the rough glass was laid had formed an integral part of the old polishing and grinding ma-

[4] "Improvements in Flat Glass Manufacture," *American Glass Review,* XLVII (May 19, 1928), 15.

[5] *Glassworker,* April 7, 1923, p. 11.

[6] *Glassworker,* April 7, 1923, p. 11.

chines and they were therefore idle while the plates were being laid or turned over. As an hour was required to lay or turn over a plate, a process which was repeated several times during the grinding and polishing operation, the time when the machine was in enforced idleness was an item of considerable importance. In order to overcome this drawback, new machines were designed about 1900 which employed removable decks or tables, usable with any grinder or polisher. A number of extra tables were provided to obviate idleness for all machines. In the new process the rough glass was laid on a table, placed under a grinder, and was ground, smoothed, and transferred to a polishing machine to have the same surface polished. In the meantime the grinder was reloaded with a new table and plate of glass. After the ground side of the first plate had been polished, the glass was turned and the identical operations repeated. This method necessitated handling the glass only three times, instead of nine. Furthermore the grinding and polishing machines stood unused only a few minutes.[7]

Other improvements in methods of polishing plate glass that were instituted in the early years of the twentieth century included betterment of polishing materials and more accurate determination of proper polishing block pressure as well as determination of the most efficient speeds for both grinding and polishing.[8] Furthermore, there were numerous minor improvements such as proper grading of the sand and emery used in grinding, and the advent of electrically driven machinery.

Later improvements in the casting hall department of plate-glass manufacture comprised many innovations in handling of pots and plates. In these improvements electricity played an important role. Though the pot method of melting was retained, furnaces were improved and enlarged. Moreover, greater attention was directed to the technique of pot-making than had been the case previously. Various progressive steps were taken in the composition of the pot batch, in the study of the properties of the several types of clays, and the role of temperature and hu-

[7] *Glassworker,* April 7, 1923, p. 11.
[8] *Glassworker,* April 7, 1923, p. 11.

midity in the pot drying process. The capacity of melting receptacles also was much enlarged and consequently the size of the plates that could be successfully cast.[9]

The improvements enumerated above reduced the importance of manual skill in plate-glass manufacture below the level required in 1890. Moreover, the entire process of casting and finishing was substantially accelerated. In 1889, before the first of the innovations just described was introduced, it took about ten days to produce a sheet of polished plate; by 1923 the same procedure consumed but thirty-six hours. The time required for annealing had been reduced from four days to a few hours and the time for grinding and polishing from several days to a matter of hours.

The improvement in production methods and techniques had been sufficiently general and extensive to cause the typical plate-glass factory of 1920 to contrast markedly with the plant and equipment of early days.[10] Nearly every operation was carried out with the help of mechanical appliances. The batch was loaded into a preheated pot either by means of a hand-filled iron ladle or by a semiautomatic charging ladle. The pot was removed from the furnace by means of tongs carried by an overhead crane and was delivered to a mechanical teeming crane. Here one of the few hand operations took place — skimming the pot, in which process two men removed impurities from the top of the glass with special tools designed for the purpose. The jaws of the teeming crane were then clamped upon the pot, which was transported to the opposite side of the casting table and placed in position for teeming. The "teem" was accomplished by moving the crane forward on its overhead runway, at the same time dumping the contents of the pot on the table. The roller then moved forward, passed over the plastic glass,

[9] *Glassworker,* April 7, 1923, p. 11.

[10] *Glassworker,* April 7, 1923, p. 11; *Glass Industry,* January 1921, p. 3. In 1921 it was said that the modern grinding machines bore no comparison to those of 1900 The former were of rigid construction and did not deflect one thirty-second of an inch. The old machinery had been flexible and flimsy. The time wasted in former years by starting the grinder at a slow speed to avoid breakage had, in 1921 been eliminated. The runners were lowered gradually on the glass to cut off the high spots first, but the machine began at almost full speed.

and finally moved onto wedges to permit the glass plate to move beneath it into the first oven of the lehr. The whole of this operation was accomplished by one man stationed at electric controls. The glass moved forward in the lehr by the propulsion of electrically driven pushing tools, and at the end of the lehr slid upon a car equipped with electrically operated rollers. The sheet was transferred by this car to the cutting tables. The cutting tables also possessed rollers below their surfaces, making possible mechanical manipulation of the glass in the final stage of rough plate-glass manufacture. During the entire process the part played by manual labor had been reduced to a minimum; only at the cutting table was hand work of any significance.

The grinding and polishing of plate glass was accomplished by means of the improved rotary transferable tables described above. These were frequently thirty-five feet in diameter and held sheets of various sizes so fitted together as to fill the deck. The grinding tools consisted of blocks of iron set into the under surfaces of two smaller circular tables. Water and sand were fed to the machines mechanically. Frequently a mechanical device was also employed to reclassify the sand and return it to the grinders. The latter innovation was said to have reduced the grinding time by about one-half. The polishing of the plate was performed in a similar manner; certain of the technical features were varied but, as in grinding, use of mechanized appliances was almost complete.[11]

Not until the early years of the period following World War I did revolutionary change in the process of plate-glass production take place. The continuous method of plate production was first conceived and developed not by glass manufacturers but by automotive interests. In 1920 the Ford Motor Company began experiments designed to bring forth a plate-glass process more efficient, more rapid, and more direct than any then existing.[12] In a remarkably short time these experiments developed a new method and brought it to the point of commercial practicability. The plate-glass manufacturers themselves soon adopted the

[11] The above description is from Tillotson, "The Manufacture of Constructional Glass in the United States," *Journal of the Society of Chemical Industry,* XL (1921), 155T; *Glass Industry,* January 1921, p. 3.

[12] *American Glass Review,* May 28, 1927, p. 17.

theory of the new system. In consequence the history of the American plate-glass industry from 1920 to 1929 is dominated by the growing importance and increasing utilization of "continuous" plate-glass manufacture.

In the perfected continuous process the glass was melted in large continuous tanks similar to those used in the container industry. Below the refining chamber of the furnace was located a discharge spout, an opening through which the glass flowed in a continuous stream.[13] From the spout, the molten metal passed downward along an inclined plane to a moving table and under a roller, from whence it emerged in the form of a flat sheet of the required thickness and width. The glass then went through a long annealing lehr, at the far end of which it was cut into plates of the desired length; the plates then were transferred to the finishing department. The entire operation, from the back of the melting tank (where the batch was automatically fed into the furnace) to the cold end of the annealing lehr, was continuous and completely automatic. The workers required by a casting unit were the following: two batch mixers to prepare and weigh the batch and deliver it to the automatic mixing apparatus; one furnace man for each furnace and one glass skimmer for two furnaces to supervise the proper melting of the glass in the tank; one roller operator to control the speed of the casting table and the roller; and one oiler to keep all the machinery involved in proper working condition. At the end of the lehr a cutter was provided to examine the glass for defects and cut it into sheets of required lengths. Two transfer men delivered the separate plates to the finishing department. The total number of workers necessitated by the continuous casting process was thus approximately ten (including the portion of the labor of the chief foreman and his assistants allotted to a particular casting unit) as compared with the fifty or more workers that constituted a casting shift in the old or "discontinuous" process.

The principles and actual operations of grinding and polishing plate glass in the continuous method were exactly the same as in the discontinuous method.[14] In the latter process, however,

[13] The following description is from *Productivity of Labor*, pp. 182–184.
[14] The following description is from *Productivity of Labor*, pp. 184–187.

the plates were laid out on individual round tables which were then moved from one section of the finishing department to another; in the continuous process the tables holding the plates moved forward uninterruptedly on a long and narrow conveyor and the various operations were performed while the glass was in motion. Furthermore, the laying-out process was much simpler than in the discontinuous method; the tables used were rectangular and comparatively small so that only one plate was placed upon a table. After the glass emerged from the last grinder and before it started under the polishing machines, it was automatically cleaned. Also if any breakage had occurred by this time, the plate was either replaced or patched with plaster of Paris to avoid further damage under the polishing machines. The polishing machines were built exactly like the grinding apparatus, each constituting a separate unit and controlled by an independent motor. The rouge and water used for polishing were supplied automatically as the glass passed from one unit to another. After emerging from the last polishing unit the table was washed, the plate reversed, and by use of a semicircular track pivot, started on a second journey similar to the first. At the end of the second conveyor the plate of glass, by then ground and polished on both sides, was stripped from the table, washed in a diluted acid solution and transferred to the cutting department. An average of 24½ workers were required to operate a single complete finishing unit.

It has been said that use of the continuous process of plate-glass manufacture effected a direct labor cost reduction of about 25 per cent on rough plate production and 33 per cent on polished glass.[15] Despite these savings the older discontinuous process had not by 1929 been wholly superseded by the newer technique, which proved to be highly effective in the making of small plates and hence was widely used for that purpose. In 1927 only four of the eighteen plants then in existence, three of them owned by automobile manufacturers, employed continuous flow. By 1929, however, one-half of total capacity had been transferred to the new method.[16]

[15] *Productivity of Labor*, p. 14.

[16] Jerome, p. 103.

Increase in Production

Table 21 presents a statistical history of the American polished plate-glass industry from 1890 to 1929. It reveals certain pertinent facts concerning the evolution of the industry in this period. The great and rapid growth of output in both value and quantity stands in sharp contrast to the high degree of invariability of the number of establishments. This comparison reflects the continually increasing size of the productive unit. The rate of development measured by quantity of product was precipitous and more or less regular before 1914; afterward variation in output was generally positive but spasmodic, a circumstance apparently explained primarily by fluctuating domestic market conditions. As in the case of the three other major branches of the American glass industry, except for the interval 1921–1923, the trend of average unit values was downward and consistently below that of wholesale prices. The sharp price and quantity rise of 1923 is explained by heavily and suddenly augmented domestic demand conditions, as is the great increase of imports in 1923 and 1925. The accelerated relative fall of unit values between 1923 and 1929 is doubtless a manifestation of the effects of the continuous process of plate-glass manufacture, introduced shortly after 1920. Finally the large percentage of domestic production of imports plus domestic production makes abundantly clear the overwhelmingly dominant position of domestic producers in the American market. In 1890 production of polished plate glass in the United States represented 82 per cent of combined imports and domestic production. In 1914 this figure was 96 per cent and in 1929, by which time foreign producers had fully recovered from the devastations of World War I, it was 95 per cent.[17]

For types of domestic plate-glass production other than polished, no comparable statistical appraisal can be supplied. Consistent and complete census reports for such subdivisions of the plate-glass industry seem to be unavailable. There can be little doubt, however, that American producers were in at least as

[17] Domestic production of silvered polished plate glass is not discussed since the present inquiry is not concerned with secondary glass manufacturing.

TABLE 21

TOTAL PRODUCTION, AVERAGE UNIT VALUES, AND IMPORTS OF POLISHED PLATE GLASS, 1890–1929

Year	Total Production				Index of average unit values[a] (per cent)	Bureau of Labor Statistics wholesale price index (per cent)	Total imports of polished plate (not including silvered) (thousand dollars)	Domestic production as percentage of imports plus domestic production
	Number of establishments	Value (thousand dollars)	Quantity (thousand sq. ft.)	Increase in quantity (per cent)				
1890	16	4,172	9,100	..	..	..[c]	920	82
1899	16	5,159	16,884	85	100.0	100.0	230	96
1904	17	7,978	27,293	62	95.7	109.8	880	90
1909	..[b]	12,205	47,370	73	84.6	124.6	510	96
1914	19	14,774	60,384	27	80.3	128.7	630	96
1919	17	33,348	56,824	−6	192.4	273.4	10	99
1921	..[b]	37,261	56,239	−1	217.0	188.2	2,070	95
1923	17	66,103	94,470	68	229.4	188.7	16,050	80
1925	19	57,207	117,369	24	159.8	203.3	7,150	89
1927	18	44,258	118,124	1	122.8	..[c]	4,440	91
1929	15	50,191	148,743	26	110.6	..	2,460	95

Data from *Productivity of Labor in the Glass Industry* and Census of Manufactures for the years specified; import data from *Commerce and Navigation*, for the years specified and includes polished plate, unsilvered, and polished plate, unsilvered, when bent, etc.

[a] Index of average unit values on 1899 base.

[b] Not reported.

[c] The wholesale price index is one recomputed by the compilers of *Productivity of Labor in the Glass Industry* and hence cannot be continued.

favorable a position in these fields as in the polished plate market. Value and quantity of output of obscured glass (including cathedral, skylight, and rough plate) in 1890 was $781,000 and 9,560,000 square feet, which represents 90 per cent of the combined value of imports plus domestic production. The figures for domestic production of obscured glass during the early twentieth century are as follows:[18]

	Value (dollars)	*Quantity (sq. ft.)*	*% of imports plus domestic production*
1899	808,000	13,150,000	99
1904	976,000	21,889,000	90
1909	1,396,000	23,022,000	92
1914	2,443,000	43,171,000	95

The period after 1920 witnessed, in addition to the remarkable expansion of the polished plate-glass industry, notable development in rough wire, laminated, and other special types of plate-glass production.[19] Indeed, a new and most significant feature of the whole history of plate-glass manufacture after 1920 was the invasion by plate and window glass of markets formerly restricted to one or the other. The development of the manufacture of sheet window glass made possible the production of window glass which would serve many of the purposes for which thin plate glass had formerly been employed, and the introduction of continuous plate-glass manufacture opened new markets for the sale of plate. In this evolution the distinction between plate and window glass tended to disappear.[20]

[18] The import data upon which these computations are based are *Commerce and Navigation* figures, adjusted.

[19] Because of the increasing importance of laminated or safety glass after 1920 the fortunes of the plate-glass industry became more and more closely allied with the development of the automobile industry. It is this fact that explains the entrance of automotive interests into plate-glass manufacture. In 1927 five of the plate-glass factories then in existence were owned by the Pittsburgh Plate Glass Company and produced 50 per cent of the total output; the eight controlled by automobile manufacturers were responsible for 35 per cent of production. ("Tariff Investigation of Plate Glass," *American Glass Review,* XLVI [April 2 to April 30, 1927].)

[20] "Evolution of the American Plate Glass Industry," *Glass Industry,* XI (July, 1930), 151–152.

Tariff Policy

The tariffs imposed on imports of polished plate glass from 1890 to 1913 continued to be heavy. The act of 1890 retained the schedules provided by the enactment of 1883 with but one exception.[21] The legislation of 1894 retained the 1890 specifications for the first two size brackets but reduced those on the two largest size groupings in one case slightly, in the other significantly. The act of 1897 accepted the reductions of 1894 on the larger sizes but raised the duties on the two smaller classifications by 60 and 25 per cent. In 1909 these same brackets were again augmented by approximately 25 per cent.[22] The Democratic tariff of 1913 made the first important reductions in the polished plate schedules since the Civil War, the new duties averaging somewhat more than 35 per cent less than the rates of 1909.[23] The average ad valorem equivalents of the specific duties varied over the period 1890–1915, from less than 40 per cent on sizes not over 24 x 30 to as much as 100 per cent on the larger sizes.[24] For all sizes protection averaged approximately 70 per cent.

The duties on rough, rolled, or fluted plate glass underwent little change between 1883 and 1913. The act of 1890 reaffirmed the rates of 1883, that of 1894 set the provision for the largest sizes at a somewhat lower level, the act of 1897 made increases in the two largest classifications, and the tariff law of 1909 made no change whatsoever in the prevailing specifications. The tariff

[21] The duty on sizes not above 10 x 15 inches was raised from \$.03 to \$.05 a square foot (*Tariff Acts*, p. 369).

[22] *Tariff Acts*, pp. 465, 545, 700.

[23] *Comparison of Tariff Acts*, p. 29. The individual duties in dollars per sq. ft. on polished plate glass were as follows:

	1890	1894	1897	1909	1913
Not above 16 x 24 inches	.05	.05	.08	.10	.06
Above 16 x 24, not above 24 x 30 inches	.08	.08	.10	.125	.08
Above 24 x 30 inches				.225	.12
Above 24 x 30, not above 24 x 60 inches	.25	.225	.225		.
Above 24 x 60 inches	.50	.35	.35	.	.

[24] Data from *Commerce and Navigation*, 1890–1920. The ad valorem equivalents for the World War I period mean little because of the abnormally small quantities imported. To avoid severe distortion, the rates for the years 1916–1920 have been omitted from the averages employed above.

of 1913, however, incorporated substantial reductions.[25] The average ad valorem equivalents of the specific rough plate duties for the period 1890–1915 were about 25 per cent for sizes 24 x 30 inches or below and for sizes above 24 x 30, approximately 40 per cent.[26]

By the tariff act of 1922 the plate-glass duties of 1913 were abrogated and new rates imposed which represented average increases of 50 per cent on fluted, rolled, or rough plate and about 80 per cent on polished glass. American producers were nevertheless dissatisfied with the degree of protection provided. They exerted continuous pressure for an investigation of foreign and domestic costs of production and in 1923–24 induced the Tariff Commission to undertake an inquiry.[27] Data were obtained from all producers in the United States and from one American-owned company in Belgium, the principal exporting country. The Belgian companies at first declined to supply information, but later, in 1925 when with domestic importers they succeeded in reopening the hearings, the Union Commerciale des Glaceries Belge submitted data on costs. In 1926 the Tariff Commission engaged in further field work and the next year conducted still more hearings. At the later sessions Belgian manufacturers of plate glass and domestic importers contended for a 50 per cent reduction in the existing duties; the domestic producers and jobbers, on the other hand, demanded an exactly converse change.[28] Many of the hearings were marked by bitter controversy centering about the effect of the continu-

[25] The individual duties in dollars per sq. ft. on fluted, rolled, or rough plate were as follows:

	1890	1894	1897	1909	1913
Not above 10 x 15	.0075	..	.	..	..
Above 10 x 15, not above 16 x 24	.01	.	..	..	..
Not above 16 x 24	..	.0075	.0075	.0075	.005
Above 16 x 24	..	..		.	.01
Above 16 x 24, not above 24 x 30	.015	.01	.0125	.0125	.
Above 24 x 30	.02	.015	.0175	.0175	.

[26] Data from *Commerce and Navigation,* 1890–1920. The ad valorem equivalents from 1916 to 1920 have been omitted for the same reason as in the case of polished plate glass.

[27] "Tariff Investigation of Plate Glass," *American Glass Review,* April 2 to April 30, 1927.

[28] "Testimony at Tariff Hearings," *National Glass Budget,* XLIII (May 14 to July 16, 1927).

ous process upon the relation of foreign and domestic costs. In the report which the Tariff Commission finally made to the President in 1928, three members of that body recommended increased rates and three recommended decreased tariffs.[29] The President chose the former alternative and in 1929 raised the plate-glass duties approximately 25 per cent.[30] Translated into ad valorem terms the specific duties on rough plate glass averaged somewhat less than 20 per cent during the years 1920–1922 and 1927–1929. On polished plate the averages approximated 50 per cent for the same time periods. Between 1923 and 1926 the average ad valorem equivalent for rough and polished plate combined amounted to about 30 per cent.[31]

The history of American plate-glass manufacture before 1920 is a chronicle of steady if nonrevolutionary technical progress. Although technological improvement was not confined to the United States it can be said with accuracy that America after 1890 became an increasingly important innovator in plate-glass making and an acknowledged leader in large-scale production and cost reduction.[32] The development in grinding and

[29] *National Glass Budget,* XLV (July 27, 1929), 3.

[30] "President Increases Tariff on Plate Glass," *American Glass Review,* XLVIII (January 26, 1929), 23. The individual duties in dollars per sq. ft. provided by the acts of 1913 and 1922 were as follows (*Comparison of Tariff Acts,* p. 29; "Interesting Testimony on Plate Glass," *American Glass Review,* XLVIII [January 26, 1929]):

	1913	1922
Fluted, rolled, or rough plate		
Not above 384 sq. in.	.005	.0075
Above 384 sq. in.	.01	.015
Polished plate, unsilvered		
Not above 384 sq. in.	.06	.125
Above 384 sq. in. not above 720 sq. in.	.08	.15
Above 720 sq. in.	.12	.175

[31] Between 1920 and 1922, and 1927 and 1929, imports included in the averages comprise non-processed polished or rough plate with or without a contained wire netting. Between 1923 and 1926 a portion of rough and polished plate are reported together and, to maintain comparable figures, the remaining portions of rough and polished plate have been combined. The items included 1923–1926 are the same as 1920–1922 and 1927–1929 except that a certain portion of processed rough plate cannot be eliminated from the non-processed figures.

[32] "Early Plate Glass Making," *National Glass Budget,* XXI (September 9, 1905), 1; "Broadcasting the Story of Plate Glass," *American Glass Review,* XLV (June 12, 1926), 31; "Plate Glass and the Tariff," *National Glass Budget,* XXXIV (September 28, 1918), 1.

polishing equipment, the improvements in casting and annealing, the significant shortening of the length of process, the persistent mechanization, and the reduced importance of the skilled and non-skilled labor factors and labor cost permitted American manufacturers to achieve a position of notable competitive strength.[33] To determine the exact level of this cost position is difficult. A wealth of comment is to be found in the reports of the tariff hearings of 1909.[34] Indeed, the major portion of the testimony on the glass schedules is devoted to consideration of the American plate-glass industry. The testimony of the two interested and antagonistic parties, the importers and the producers, however, is in most cases flatly contradictory, and it is not easy to compound the many diverse statements into truth. The domestic plate-glass manufacturers were contending for a single specific tariff applicable to all sizes. There seems to be no doubt whatsoever that this procedure, if it had been adopted, would have resulted in a very heavy increase in the taxes on smaller sizes and a lowering of the duties on the higher brackets, in effect a net increase of protection.[35] The manufacturers' explanation of the cause of their contended higher costs appears questionable and seems to be refuted by the briefs of the importers. The producers laid great stress on high wages, inefficiency of domestic workmen, and unfavorable freight rates. Evidence already presented indicates that continuing mechanization had, even by 1909, deprived higher wages of prime importance in plate-glass production and the submissions of the importers also supports this contention. Furthermore, the claim that American workmen were inefficient was never substantiated by the evidence adduced. Although the importers agreed that American costs were still higher than foreign, both the importers' evidence and the confused and sometimes wandering testimony of the manufacturers suggest that the cost differences were nowhere near the proportions of the specific tariffs. The attempts of the plate-glass companies to prove that their industry was languish-

[33] *Tariff Hearings, 1909,* pp. 1124–1220.

[34] See also "A History of Plate Glass in America," *American Glass Review,* LIII (December 6, 1933), 9.

[35] It will be recalled that the tariff act of 1909 as finally passed provided for substantial increases in the specific duties on small sizes.

ing seem ill-advised in light of their already great control over the domestic market and the great expansion of output that had taken place between 1890 and 1909. American glass producers cited one type of evidence, however, that seems to have been both accurate and relevant to the question of the tariff. This concerned the existence of combination among foreign plate-glass producers. It is indisputably established that from the first years of the twentieth century and possibly earlier, a European plate-glass syndicate had exercised effective control over production and prices. This syndicate employed an intricate and highly developed system of monopolistic pricing based upon geographical discrimination. Selling prices were said to have been manipulated according to the demand and competitive conditions of each consuming area. Quotations for the American trade reportedly were set very low, a circumstance which offered a substantial competitive obstacle to domestic producers. It is probable, furthermore, that these same activities of the syndicate provided the major difficulties which American plate-glass manufacturers encountered in the export markets of the world.[36]

There seems to be little doubt that the competitive position of American producers of plate glass improved between 1890 and 1920; it seems equally certain that the differential between domestic and foreign costs was substantially reduced in that time period. The course of plate-glass exports, first reported in 1908, lends support to these statements; for, though the quantity of exports remained small until the years of World War I, the fact that an export trade appeared is of considerable significance (see Appendix, Table 6). Throughout the same period, despite improvement of competitive position, the tariff advantage bestowed upon domestic producers continued to be very heavy. There are strong indications that a considerable portion

[36] *Tariff Hearings, 1909,* pp. 1124–1220; *Tariff Hearings, 1913,* pp. 454–458; "Plate Glass Problems of Europe," *National Glass Budget,* XVII (June 15, 1901), 1; "The Tariff on Plate Glass," *National Glass Budget,* XVIII (May 16, 1903), 4; "Window Glass Affairs," *Glassworker,* XXXII (July 4, 1914), 1; "Answer Is Made to Charges against United States Plate Glass Trade," *Commoner and Glassworker,* XLI (December 31, 1921), 1; "Digest of Tariff Testimony," *National Glass Budget,* XXXIV (September 28, 1918), 4; "Plate Glass and the Tariff," *National Glass Budget,* September 28, 1918, p. 1; "Glass Industry Facing Many Great Obstacles," *Glassworker,* XXXIX (February 28, 1920), 21.

of this tariff protection was unnecessary, and there is some basis for the belief that it was utilized by American producers to support their own monopolistic practices. It is scarcely necessary to add that the uncontroverted fact that plate-glass prices fell steadily after 1875 is not incompatible with such activities; costs may well have moved downward more rapidly than prices.[37] One of the major topics of question and testimony before the Committee on Ways and Means in 1909 was the subject of combination and control of prices. A careful reading of the committee's hearings leads to the opinion that price fixing and price restraints were generally known to have been practiced in the American plate-glass industry after and probably before 1900.[38] In this activity one large company seems to have been the acknowledged "price leader." The presence of one very large producer and a relatively small number of producers in the field as a whole set a perfect stage for the various forms of price and production control. Though it is difficult to assemble evidence upon this matter, it may be noted that at the 1909 tariff hearings the importers supplied samples of non-importation agreements which, it was said, were required of American wholesale purchasers of plate glass as a prerequisite to purchase from American producers.[39] It is also notable that in these hearings the representatives of the predominant company made every effort to minimize the extent of the company's earnings and that the importers' briefs contained what appears to be accurate evidence of prosperity among plate-glass companies in general and the leading company in particular.[40]

As in the case of window-glass manufacture, it cannot be said that tariff protection was unnecessary for the maintenance of the exact degree of prosperity which characterized the American plate-glass industry after 1920. There seems to be little doubt that imports, particularly at the coastal areas, would have been greater than they were had there been no tariff at all. The necessity for the heavy duties imposed after 1920 and es-

[37] See *Tariff Hearings, 1909,* p. 1216; *Tariff Hearings, 1913,* p. 456.

[38] See *Tariff Hearings, 1909,* pp. 1124–1220.

[39] *Tariff Hearings, 1909,* pp. 1201–02.

[40] *Tariff Hearings, 1909,* pp. 1124–1220.

pecially the increase of 1929 seems, however, highly questionable. Several facts support such skepticism. In the first place the sharp rise of imports in 1923 and 1925 appears to have been more a result of the temporary inability of American factories to meet the requirements of a suddenly and precipitously expanded domestic demand than a deterioration of the competitive status of American producers. Secondly, long before the tariff increase of 1929 had become effective, the trend of importation had turned sharply downward and was moving consistently toward levels which made foreign plate glass an insignificant factor in domestic markets. Finally, the strong recovery of the export trade after 1926 certainly does not indicate any increasing inferiority of domestic cost position.[41]

A certain amount of tariff protection to the American plate-glass industry after 1920 may have been justified on the basis of cost disparity, if full equation of foreign and domestic production costs be considered a proper goal of economic policy. Some advantage to the domestic producer might, under certain circumstances, have also been deemed equitable because of the discriminatory price activities of powerful and long-established foreign plate-glass combinations, though the pleas before the Tariff Commission and the Committee on Ways and Means do not seem to stress this point vigorously.[42] There is, however, sufficient evidence to suggest that the tariff portection bestowed upon the domestic plate-glass producers after 1920 was greater than was warranted by the disabilities of a powerful and highly mechanized mass-production division of American industrial

[41] In 1929 it was reported that American plate-glass exporters, like the foreign, were selling in Canadian and Australian markets at prices substantially lower than those quoted for this country (*National Glass Budget,* XLV [July 27, 1929], 3).

[42] "Plate Glass Problem of Europe," *National Glass Budget,* XVII (June 15, 1901), 1; "The Tariff on Plate Glass," *National Glass Budget,* XVIII (May 16, 1903), 4; "Window Glass Affairs," *Glassworker,* XXXII (July 4, 1914), 1; "Digest of Tariff Testimony," *National Glass Budget,* XXXIV (September 28, 1918), 4; "Plate Glass and the Tariff," *National Glass Budget,* XXXIV (September 28, 1918), 1; "Glass Industry Facing Many Great Obstacles," *Glassworker,* XXXIX (February 28, 1920), 21; "Answer Is Made to Charges against United States Plate Glass Trade," *Glassworker,* XLI (December 31, 1921), 1; "Tariff Investigation of Plate Glass," *American Glass Review,* XLVI (April 2 to April 30, 1927).

life. Between 1890 and 1929 the plate-glass industry, being by its essential nature highly congenial to the type of industrial production which America was able to pursue with advantage, moved nearer and nearer a stage of competitive equality and superiority. The steps of technical progress by which this development proceeded were in a path well laid out by the evolution of large-scale production in American industry generally and cannot be attributed in any connective sense to a protective tariff. As has been already pointed out, it seems probable that a major portion of the plate-glass tariff advantage in force between 1890 and 1929, particularly in the later years, was unnecessary for maintenance of the domestic industry. Finally, it appears likely that this superfluous tariff protection facilitated, if it did not make possible, a certain amount of price control and price maintenance in the industry.

CHAPTER XII

CONCLUSION

GLASSMAKING WAS one of the earliest industrial arts practiced in the American colonies. The difficulties that beset the glassmaking firms of colonial days were, none the less, so numerous and persistent that these pioneer ventures were notably unsuccessful. Causes of failure included the restricted demand of colonial householders for glass products generally, a preference for the merchandise of the home countries, the technical problems encountered in adapting the practices of an ancient craft to a frontier land, and the fundamental tenets of British colonial economic policy. During their short-lived operation, colonial glasshouses produced for the most part bottles, beads, and window glass — relatively crude objects serving primary needs. Shortly before the Revolution, however, two plants undertook the manufacture of lead crystal. These glassworks, operated by Stiegel and Wistar, produced glass of considerable artistic merit much prized by antiquarians of today.

After the Revolution new glassmaking ventures appeared in Massachusetts, Connecticut, Maryland, Virginia, and Western Pennsylvania. This period constituted the first phase of substantial progress in the development of the glass industry and laid the foundation for its permanent establishment. The events that led to the War of 1812 encouraged further development of American glassmaking. The end of the war, on the other hand, temporarily halted expansion of the industry and brought distress to many of the glasshouses that had recently begun operations. The long pent-up stream of English manufactures flooded the country and the prices of all factory-made commodities, glass among them, declined sharply. In general, the years immediately following the peace were years of depression and the prospects of the glass industry appeared to contemporary pro-

ducers to be highly uncertain and forbidding. The economic perspective of these same producers was soon to change, however.

By 1820, it had become apparent that glass manufacture had been firmly established in the economy of the young nation. At that time window glass was the product of greatest importance in the industry with common or green glassware ranking second and flint glass third. In terms of quality, glass products made in America in 1820 were, on the whole, inferior to comparable foreign manufactures. Nevertheless there were exceptions, notably in the case of Boston crown window glass and certain of the flint-glass products made by the East Cambridge and Pittsburgh works. By 1820, also, it had become obvious that fuel requirements were to dominate the industrial localization of the industry in America as it had in other countries. At that time all but a few of the works in operation melted batch by wood fire and were therefore to be found in or near heavily wooded areas.

General economic revival gradually eliminated the depressed conditions pervading the industry just prior to 1820 and restored the upward trend of industrial development. Between 1825 and 1831 domestic production experienced an era of expansion that was shared by all branches of the industry but which was particularly marked in the case of flint and common output. Moreover, this general upsurge of home production of glass products was maintained until the Civil War. Over this period flint and lime glassware continued to rise in importance, primarily as a result of an unprecedented increase in glass manufacture by pressing.

Between 1860 and 1890 the development of the glass industry followed a pattern set by the industrial expansion of the national economy as a whole. Three events distinguish the history of this period. These were the introduction of new fuel and new glass-melting methods, the first successful large-scale production of plate glass, and the rise of organized labor.

The discovery of natural gas and its subsequent utilization in firing gas furnaces had a profound effect upon the location of the industry. Previously coal had replaced wood as the accepted glassmaking fuel and had largely shifted glassmaking plants to

the coal-producing areas. Gas, however, was an almost perfect glass-melting medium and therefore was rapidly and widely adopted. Released from the ties of the coal districts, the glassmaking industry promptly reverted to the migrant habits characteristic of the industry's wood-burning era, in this instance following the map of natural gas discoveries. The fact that the American glass factory of the day was still typically a small-scale, small-investment enterprise facilitated the migratory process.

In contrast to most other branches of glass manufacture, efficient plate-glass production did not depend primarily upon the dexterity and skill of the worker. Like glass pressing, glass casting was a process of relatively simple technique requiring no intricate and adaptive manipulation by workers; it was repetitive rather than discretionary. For these reasons plate-glass manufacture possessed great potentialities for thoroughgoing mechanization, application of power, and large-scale production. Such potentialities, partially realized for the first time in the latter portion of the period 1860–1890, foretold the great expansion and strong competitive position that the industry was to achieve in the twentieth century.

A significant development in glass manufacture from 1860 to 1890 was organization of the workers. The craft unions that arose in the window-glass, container, and flint and lime branches of the industry had, as background, long-standing traditions of craftsman solidarity in European glass-producing countries. This fact in part explains the rapidity and relative durability of the unions' organizing achievements. Other factors that also played important roles in these successes were the cardinal importance of the skilled worker in most glass manufacturing processes, a mounting desire for increased wages as well as improved and uniform working conditions, and alert labor leadership.

Up to 1820 the methods, processes, and techniques of glassmaking in the United States were closely similar to foreign practices. Not only the techniques of shaping and forming glass objects but also preliminary procedures involving raw materials, fuels, furnaces, annealing ovens, and pot-making were borrowed from the older glassmaking countries. Nor did any significant

general advance in industrial methodology mark the history of American glass manufacture prior to the Civil War. This period was notable in America for only one important technical achievement — the development of new and improved processes for glass manufacture by pressing. American glassmakers attained a position of competitive advantage in pressed glass because that process was essentially appropriate to a high wage country which, even in its early years, had come to appreciate that mechanical processes held the key to its industrial preeminence. Pressed glass manufacture was the first branch of the glass industry to take advantage of the basic characteristics of the American industrial economy.

Not until the last quarter of the nineteenth century did other significant technological improvements appear in glassmaking. The introduction of gas-fired furnaces came first and was followed by the substitution of tank melting for the ancient system of melting batch in pots. Soon thereafter mechanization of glass-forming methods themselves appeared in the major branches of the industry and set in motion a series of progressive technical and economic adjustments that eventually wholly transformed glassmaking in America.

The history of the glass industry after 1890 is dominated by the mechanical revolution. In window-glass manufacture three well-defined industrial phases may be distinguished. The first phase covers the years of turbulent intra-industry strife from 1890 to 1903. The second, characterized by the advent of the Lubbers cylinder blowing invention and the rise to preëminence of machine cylinder production, embraces the interval between 1904 and 1920. The third phase is marked by the introduction of the Colburn drawing machine, fully automatic production, displacement of machine cylinder methods by sheet drawing, and the disappearance of the ancient craft of hand window-glass blowing; this period comprises, roughly, the decade of the 1920's.

In container production American inventive ingenuity first solved the problem of forming the bottle and then the problem of gathering. The first phase of mechanical revolution in bottle manufacture was therefore an era of semiautomatic machinery

for which gathering was done by hand. Twentieth-century solutions to the problems of automatic feeding and other forms of full automatic production, including the spectacular Owens invention, completed the cycle of mechanical revolution in container manufacture. By 1929, American bottle and container production had passed from handicraft to machine process and the once dominant hand industry had been reduced to a narrow and quantitatively unimportant field.

The pressed and blown branch of the glass industry was less affected by the mechanical revolution than container and window-glass manufacture. In 1890 pressed-glass production was already largely in a semiautomatic stage and the prevalence of small-scale, job-lot production of the wide variety of articles in this branch of glassmaking minimized the pressures for new and improved machinery. On the other hand, development of mechanized devices in certain areas of the blown ware division of the industry was pronounced. After 1890 repeated efforts were made to eliminate hand production in many types of blown glassware manufacture. Not all were successful, however, and as late as 1929 a substantial number of blown products were still dependent upon the art of the glass blower. But in certain lines, especially in the manufacture of lamp chimneys, electric light bulbs, punch tumblers, and glass tubing, there were revolutionary triumphs.

Perfection of automatic feeders eventually made possible completely mechanized pressed-glass production. Later, introduction of the continuous process brought full automatic production to plate-glass manufacture.

Recorded labor history in the American glass industry prior to 1860 is fragmentary. In general there seem to have existed no national or regional unionization and such local agreements as may have been made from time to time appear to have had no appreciable effect upon conditions in other areas. That the early glassmakers did, in some degree, influence wages, working conditions, and apprenticeship is suggested by recorded complaints of contemporary employers.

A feature of the history of labor in the window-glass industry after 1860 was the reign of "L. A. 300," one of the most power-

ful unions in the history of the country. This national organization of workers exercised detailed and inclusive control over productivity and apprenticeship. With a counterpart organization of glass industry employers, the union not only negotiated wages, but also attempted jointly to determine annual window-glass production and prices. Such activities led to recurrent episodes of severe intra-industry strife over price and production levels. The onset of mechanical revolution reduced prices, lowered wages, eliminated the traditional limits on output, displaced workers, and ultimately caused the demise of L. A. 300.

Like the labor organization of the window-glass workers, the Green Glass Blowers Association traced the genesis of effective labor organization from Civil War years. The bottle blowers organization was similar to the union of window-glass workers in other respects, too. Both found their fundamental source of power in regulation of the supply of labor; both were able to make such control effective because of the nature and traditions of their craft; both worked for, and established, a system of collective bargaining and negotiation. The two labor organizations differed, however, in one important respect; the green-glass blowers did not practice, with equal inclusiveness, limitation of output as an integral part of union policy. Nevertheless, mechanization of the container industry greatly curtailed the range and extent of the union's power and reduced the wages of most of its members severely.

In the flint and lime branch of glassmaking the American Flint Glass Workers' Union, a federation of lesser craft organizations, occupied a position analagous to that held by the Green Glass Blowers Association in container manufacture. Like L. A. 300, the Flint Glass Workers' Union maintained regulations regarding output, length of working periods, and apprenticeship, but among the affiliates such regulations varied appreciably. Mechanization of the pressed and blown branch of glass manufacture brought with it a significant reduction in the importance, number, and earnings of union members. In spite of this fact and for a time at least, craftsmen specializing in pressed and blown products fared better than their coworkers in the window-glass and the container industries because in this field small-lot out-

put, variation in quality and design, and multiplicity of products bolstered the demand for skilled workers.

From the beginning of the tariff history of the United States the glass industry was considered a branch of domestic manufacture needing and deserving national encouragement. This protectionist policy, first enunciated in the tariff bill of 1789, was maintained throughout the greater portion of the industry's history. Furthermore the trend in the degree of protection was generally upward, with some of the highest rates becoming effective in the twentieth century.

Until the advent of mechanical revolution it appears that foreign, especially British, costs of glass production and prices of glass products were lower than those of American manufacturers. The United States, being a high-wage country, could not have been expected to produce competitively against foreign nations in an industry such as glassmaking where, one or two branches excepted, labor cost constituted a high percentage of total cost. Until machinery transformed American glassmaking, manual processes, small-scale operation, and little mechanical equipment more than offset any economies derived from cheap American fuel. The pressed-glass industry represented an exception to these conditions. From the early years of the nineteenth century pressed glass was produced in the United States with competitive effectiveness precisely because its manufacture was well adapted to and fully utilized the basic production principles underlying American industrial efficiency. After the last quarter of the nineteenth century plate-glass production represented another exception and for closely similar reasons. Exclusive of pressed-glass and plate-glass production it may be said, therefore, that the tariff protection bestowed upon the glass industry prior to the twentieth century had as its major effect the maintenance of a level of glass production higher than otherwise would have been possible. The tariff, broadly speaking, compensated for higher domestic costs of production and sustained higher American prices. It also undoubtedly facilitated restrictive price and production policies where practiced by unions and employers.

The mechanical revolution in the glass industry eventually

brought greatly increased productivity, lower costs, and lower prices. Although all branches of glassmaking consequently improved their competitive positions with regard to foreign manufacturers, the container industry and certain areas of pressed and blown production seem to have experienced the most substantial gains. Window glass, in spite of a remarkable absolute advance did not proportionately better its position relative to foreign producers because contemporary window-glass manufacturers in competing countries themselves installed new and revolutionary production methods. In plate-glass manufacture after 1900 unfavorable differentials between foreign and domestic costs were substantially reduced, if not altogether eliminated. The tariff act of 1913, providing appreciable reductions in glass duties, did not serve as a test of the strengthened competitive position of American producers because the onset of World War I restricted international trade and seriously disrupted the foreign industries. In the postwar period high tariff protection was reinstated. For the glass industry generally the level of these new rates seems to have been unnecessarily high even for full equation of foreign and domestic costs at the most competitive locations. Indeed, it is probable that important sectors of the industry had, by this time, progressed to the point where little if any tariff assistance was required to retain a dominant influence in the home market.

The history of glass manufacture in the United States is a chronicle of continued expansion and ever-broadening economic development. Over the first hundred years of its history (roughly to 1890) the industry followed the tempo of the expanding American economy; as population grew, as income and wealth increased, as broad and far-flung domestic markets developed, American glass manufacture grew and prospered also, sending forth from its factories an ever-increasing quantity and variety of glass products. Throughout this period, however, except in the production of pressed glass and to a lesser extent plate glass, the industry followed rather than led in mechanical innovation and industrial ingenuity. Quite a contrary condition prevailed after the last decade of the nineteenth century. Although not the only glassmaking country to experiment with

methods of mechanical glass production, the United States so rapidly, so fully, and so successfully developed the potentialities of machine methods as to lead the world in their application to glass manufacture.

For industry as a whole, acceleration of mechanical innovation and of mechanization of the processes of production was an outstanding characteristic of the history of the Western world in the nineteenth century. Glassmaking, nevertheless, long remained untouched by this revolutionary force because of the complex problems posed by the physical properties of glass and by the character of the technical processes of glass-forming. The physical properties of glass made mechanical manipulation extraordinarily difficult, and the range, flexibility, delicacy, and great variety of motion practiced in manual production long appeared irreplaceable by machine operations. Eventually increased knowledge of the chemistry of glass, repeated experimentation, and application of inventive genius brought solutions to these problems. Certainly, in the history of the glass industry of the United States there is no evidence that technological improvement was causally related to a long-sustained policy of tariff protection. Rather than upon tariff advantage, the advent of industrial revolution in glass manufacture appears to have rested fundamentally upon the general requirements and prerequisites of the evolutionary process of mechanical invention. Moreover, there is substantial evidence that mechanical revolution in glassmaking was hastened in America by the existence of a high level of wages throughout all of American industry, and specifically in the glass industry — that is, a high level compared with wages in other glass-producing countries. To enter into world competition it was essential that American glassmakers find a means of offsetting this added cost — and they turned to a method which other industries had found effective, namely, mechanization.

APPENDIX

TABLE 1

VALUE OF TOTAL IMPORTS OF GLASS AND GLASSWARE, 1821–1929
(*Rounded figures, 000's omitted.*)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1821[a]	350	1846	690	1871	4450	1896	6260
1822	450	1847	800	1872	4880	1897	5670
1823	580	1848	1040	1873	6940	1898	3820
1824	420	1849	750	1874	6450	1899	4270
1825	360	1850	1070	1875	5740	1900	5020
1826	510	1851	1390	1876	4310	1901	4990
1827	530	1852	1480	1877	3950	1902	6240
1828	570	1853	1660	1878	3330	1903	7170
1829	430	1854	2190	1879	3280	1904	6600
1830	350	1855	1950	1880	5130	1905	5940
1831	510	1856	1740	1881	5860	1906	7530
1832	710	1857	1880	1882	6750	1907	7560
1833	550	1858	1660	1883	7600	1908	6520
1834	590	1859	1780	1884	7560	1909	5270
1835	720	1860	2170	1885	6330	1910	6590
1836	1090	1861	2120	1886	6310	1911	6900
1837	1000	1862	560	1887	7300	1912	6170
1838	530	1863	860	1888	7720	1913	6410
1839	960	1864	1140	1889	7740	1914	8200
1840	560	1865	1240	1890	7390	1915	4650
1841	570	1866	2510	1891	8250	1916	2300
1842	560	1867	4000	1892	8950	1917	2280
1843[b]	120	1868[c]	3080	1893	7960	1918[d]	1410
1844	310	1869	3980	1894	5070	1919	2060
1845	600	1870	4090	1895	5940	1920	8280

Data from United States Treasury Department, *Commerce and Navigation of the United States*, 1821–1929. Figures include all items in classifications employed by *Commerce and Navigation*, except 1922 and after as noted below, and the following which have been eliminated whenever separate enumeration permitted: old glass suitable only for remanufacture, soluble glass, glass enamel, fusible enamel, white enamel, frames, glass buttons, glass beads, smalts, and items included therewith.

[a] 1821–1842 year ending September 30.

[b] 1843 figure for nine months only. 1843–1917 year ending June 30.

[c] 1821–1867 import entries; 1868 and after, imports for home consumption.

[d] 1918 and after, year ending December 31.

TABLE 1 (Continued)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1921	10520	1923	25750	1925	19280	1927	18710
1922[e]	15080	1924	20460	1926	22380	1928	17110
						1929	16280

[e] In 1922 a new classification separated a portion of optical glassware from the major glass and glassware section. That those items separated had been formerly included in the major section is evident from the earlier classification. Such *new* items as appear in the new optical glassware classification have not been omitted since it is probable that they were included with the others in the earlier classification, but not specifically designated. Thus, to preserve comparable figures, for 1922 and later years the [illegible] added to the glass and glassware totals: opera and field glasses; other optical instruments and frames and mountings for the same; azimuth mirrors, sextants, and octants; [illegible] telescopes, microscopes, photographic and projection lenses, and frames and mountings for the same; spectacles, eyeglasses, goggles, and frames and mountings for and parts of the same, finished and unfinished; lenses [illegible] molded or pressed and ground and polished to a cylindrical, spherical, or prismatic form, etc. (with edges ground and unground), including plano and coquille glasses.

TABLE 2

VALUE OF TOTAL EXPORTS OF GLASS AND GLASSWARE, 1821–1929
(Rounded figures, 000's omitted)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1821	..[a]	1849	100	1877	670	1905	2250
1822	..	1850	140	1878	870	1906	2430
1823	..	1851	180	1879	770	1907	2600
1824	..	1852	190	1880	750	1908	2500
1825	..	1853	170	1881	760	1909	2170
1826	40[b]	1854	230	1882	860	1910	2800
1827	60	1855	200	1883	1000	1911	3250
1828	50	1856	220	1884	840	1912	3490
1829	50	1857	180	1885	780	1913	3380
1830	60	1858	210	1886	770	1914	2730
1831	100	1859	250	1887	880	1915	5560
1832	110	1860	280	1888	880	1916	12320
1833	90	1861	390	1889	890	1917	13550
1834	80	1862	520	1890	880	1918	15470[d]
1835	80	1863	1000	1891	870	1919	24770
1836	50	1864	790	1892	940	1920	30090
1837	40	1865	1240	1893	970	1921	14440
1838	40	1866	620	1894	920	1922	9700[e]
1839	40	1867	650	1895	950	1923	12420
1840	60	1868	610	1896	1060	1924	11580
1841	40	1869	580	1897	1210	1925	11910
1842	40	1870	530	1898	1210	1926	12520
1843	20[c]	1871	470	1899	1500	1927	11900
1844	80	1872	550	1900	1940	1928	11670
1845	100	1873	630	1901	2130	1929	13710
1846	90	1874	790	1902	1960		
1847	70	1875	690	1903	2150		
1848	80	1876	630	1904	1980		

Data from *Commerce and Navigation*. Figures include all items in classifications employed in *Commerce and Navigation* except after 1922 as noted below.

[a] Not reported 1821–1825.

[b] 1826–1842 year ending September 30.

[c] 1843 figures for nine months only. 1843–1917 year ending June 30.

[d] 1918 and after, year ending December 31.

[e] In 1922 a new classification separated a portion of optical glassware from the major glass and glassware section. In order to maintain comparable figures, the following have been added to total glass and glassware exports for 1922 and later years (see also note *e* to Table 1 for the items selected for addition): telescopes, opera and field glasses; spectacles and eyeglasses; lenses not fitted to instruments; other optical instruments (surveying instruments omitted because combined with a non-glass item).

TABLE 3

Value and Quantity of Total Imports of Window Glass, 1821–1929

(Rounded figures, 000's omitted)

Year	Dollar value	Sq. ft.	Year	Dollar value	Sq. ft.
1821[a]	..	880	1843[b]	10	410
1822	..	680	1844	10	130
1823	..	1440	1845	30	270
1824	..	1050	1846	20	180
1825	60	550	1847	80	900
1826	70	800	1848	160	2830
1827	70	570	1849	140	3800
1828	60	430	1850	200	6220
1829	50	350	1851	320	8350
1830	20	200	1852	430	11660
1831	60	460	1853	480	15260
1832	60	490	1854	620	19720
1833	80	850	1855	600	20850
1834	70	740	1856	490	15470
1835	140	2130	1857	640	20200
1836	190	2710	1858	630	19750
1837	110	1530	1859	700	20140
1838	50	630	1860	750	18830
1839	100	2450	1861[c]	820	17800
1840	60	2420	1862	160	4000
1841	140	1940	1863	270	7500
1842	80	2300	1864	340	9340

Data from *Commerce and Navigation.* Figures include: 1821–1843 window glass; 1843–1846 cylinder and crown window glass; 1846–1854 window glass; 1855–1861, broad, crown, and cylinder window glass; 1862–1864 cylinder or broad window glass and crown, plate, and all other window glass; 1865–1884 cylinder, crown, and common window glass, polished and unpolished; 1885–1890 both polished and unpolished cylinder, crown, and common window glass as well as cylinder and crown window glass, polished, silvered; 1891–1913 both polished and unpolished cylinder, crown, and common window glass and cylinder and crown window glass, polished, silvered (includes looking-glass plate 1893 and after)—cylinder, crown, and common window glass, unpolished when bent, etc.—cylinder and crown window glass, polished, when bent, etc.—cylinder and crown window glass, polished, silvered, when bent, etc.; 1914–1921 both polished and unpolished cylinder, crown, and common window glass, cylinder and crown window glass, polished, silvered—cylinder, crown, and common window glass when bent, etc.—cylinder and crown window glass, polished, when bent, etc.—cylinder and crown window glass, polished, silvered, when bent, etc., and unpolished, silvered; 1922–1929 both polished and unpolished cylinder, crown, and sheet window glass as well as cylinder and crown window glass, polished, silvered, and cylinder, crown, and sheet window glass, polished and unpolished, when bent, etc., and also cylinder and crown window glass, unpolished, silvered (1922 only) and polished, silvered, when bent, etc.

[a] 1821–1842 year ending September 30.

[b] 1843–1917 year ending June 30; 1843 figures for nine months only.

[c] 1861, 1862 figures too low, some window glass in the figures for these years for combined plate and window glass.

TABLE 3 (Continued)

Year	Dollar value	Sq. ft.	Pounds	Year	Dollar value	Sq. ft.	Pounds
1865	400	70	11040	1898	1580	3010	39720
1866	570	110	16570	1899	1770	2650	46390
1867	1550	190	40800	1900	2100	2490	51870
1868[d]	1210	347	28800	1901	1430	1930	28970
1869	1420	370	33080	1902	2210	1840	51940
1870	1450	190	34260	1903	2290	2450	62280
1871	1490	170	38730	1904	1750	1580	52680
1872	2030	200	47470	1905	940	1440	18660
1873	2500	100	47140	1906	1620	1330	35000
1874	2160	60	39860	1907	1390	1490	32100
1875	1670	50	34200	1908	1010	830	25080
1876	1330	80	28840	1909	970	830	23750
1877	1040	30	24940	1910	1070	1130	26990
1878	810	20	23050	1911	1170	1010	31090
1879	660	40	20690	1912	1100	750	24720
1880	1430	90	43950	1913	1140	830	22230
1881	1440	50	45560	1914	1310	880	28090
1882	1480	80	49300	1915	830	470	16990
1883	1600	70	50950	1916	220	140	1740
1884	2470	160	77920	1917	320	..[f]	2960
1885	1720	70	59940	1918[e]	50	..[f]	430
1886	1390	80	54570	1919	130	..[f]	970
1887	1490	200	61630	1920	800	170	6070
1888	1520	390	70510	1921	2820	280	48260
1889	2690	3420	75960	1922	2900	700	53140
1890	3000	4530	70230	1923	2890	1320	47090
1891	3210	4570	61580	1924	2280	760	32150
1892	3400	4630	69150	1925	2930	780	47660
1893	3210	5130	64380	1926	3670	680	83700
1894	1850	3270	45880	1927	3280	300	86050
1895	1850	3500	49600	1928	3020	500	71360
1896	2420	4470	55250	1929	2770	160	72080
1897	2270	3800	57420				

[d] 1821–1867 import entries; 1868 and after, imports for home consumption.
[e] 1918 and after, year ending December 31.
[f] Amount below 500.

TABLE 4

Value of Exports of Window Glass, 1884–1929

(Rounded figures, 000's omitted)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1884[a]	20	1895	10	1906	70	1918	3810
1885	10	1896	10	1907	90	1919	6490
1886	10	1897	10	1908	110	1920	4100
1887	10	1898	20	1909	60	1921	450
1888	10	1899	30	1910	70	1922	180
1889	20	1900	40	1911	120	1923	260
1890	10	1901	50	1912	110	1924	190
1891	10	1902	50	1913	430	1925	140
1892	10	1903	60	1914	310	1926	180
1893	10	1904	70	1915	1440	1927	120
1894	20	1905	60	1916	3120	1928	100
				1917	3480	1929	90

Data from *Commerce and Navigation*. Exports not reported before 1884. Figures include: 1884–1907 window glass; 1908–1917 cylinder, crown, and common window glass; 1918–1929 common window glass. From 1922–1929 the figures omit other window-glass exports which are in that period reported with certain plate-glass exports.

[a] 1884–1917 year ending June 30; 1918–1929 year ending December 31

TABLE 5

Value and Quantity of Total Imports of Plate Glass, 1843–1929
(*Rounded figures, 000's omitted*)

Year	Dollar value	Sq. ft.	Year	Dollar value	Sq. ft.
1843[a]	60	10[b]	1867	1210	4370
1844	60[c]	30[b]	1868	970[h]	3130
1845	100[c]	70[b]	1869	1390	5200
1846	200[c]	110[b]	1870	1450	4830
1847	190[c]	..[d]	1871	2330	5480
1848	210	..	1872	2600	5570
1849	280	..	1873	2370	5450
1850	260	..	1874	2610	5260
1851	230	..	1875	2560	4900
1852	260	..	1876	2190	4630
1853	310	..	1877	1830	3790
1854	510	..	1878	1460	2950
1855	400	..	1879	1290	3760
1856	470	..	1880	1740	5720
1857	520	..	1881	1890	6020
1858	400	..	1882	2180	7720
1859	350	..	1883	2470	8290
1860	440	..	1884	2480	8990
1861	620[e]	..	1885	2210	8480
1862	10[f, g]	10[f]	1886	2530	9250
1863	140	470	1887	2950	10910
1864	450	1610	1888	3110	11770
1865	430	1330	1889	2010	7930
1866	840	3360	1890	1270	5660

Data from *Commerce and Navigation*. Not reported before 1843. Figures include: 1843 plate, silvered, framed, above 14 x 22 inches, and plate, polished; 1844–1846 plate, above 14 x 22 inches, and plate, polished; 1847–1860 plate, polished; 1861 plate, polished (in part, other plate combined with irrelevant items); 1862–1890 fluted, rolled, or rough plate as well as cast polished plate, unsilvered and cast polished plate, silvered (including looking-glass plates 1873 and after); 1891–1921 fluted, rolled, or rough plate — cast polished plate, unsilvered — cast polished plate, silvered — cast polished plate, silvered, when bent, etc.—fluted, rolled, or rough plate, when smoothed or otherwise obscured — cast polished plate, unsilvered, when bent, etc.; 1922–1929 same as 1891–1921, plus cast polished plate, fluted, rolled, or ribbed, ground, smoothed, or otherwise obscured and cast polished plate, fluted, rolled, or ribbed, ground, smoothed, or otherwise obscured, when bent, etc.

[a] Nine months only; 1843–1917 year ending June 30; 1918 and after, year ending December 31.
[b] Quantity too low. Quantity not reported for ad valorem taxed portion of plate imports.
[c] Value too low, portion of ad valorem taxed plate imports combined with irrelevant items.
[d] Quantity not given 1847–1861.
[e] Plus the portion of plate imports included in combined window and plate item of $50,000.
[f] Figures represent only small part of true total; other parts inseparably combined with irrelevant items.
[g] Plus the portion of plate imports included in combined window and plate item of $20,000.
[h] 1843–1867 import entries; 1868 and after, imports for home consumption.

TABLE 5 (Continued)

Year	Dollar value	Sq. ft.	Year	Dollar value	Sq. ft.
1891	1690	6310	1911	1020	4790
1892	1140	4140	1912	360	1650
1893	1040	4830	1913	310	1550
1894	550	2840	1914	770	3690
1895	740	3640	1915	130	790
1896	820	3880	1916	10	90
1897	370	1750	1917	20	40
1898	230	1060	1918	4	20
1899	260	1180	1919	20	40
1900	270	1250	1920	2530	2960
1901	810	3420	1921	2280	3690
1902	1020	4370	1922	5240	12070
1903	1460	6900	1923	16310	28340
1904	1000	5360	1924	10370	19090
1905	1200	6810	1925	7270	17210
1906	1670	8150	1926	8810	26570
1907	1550	7650	1927	4600	17370
1908	990	4740	1928	3770	18490
1909	630	3060	1929	2620	14370
1910	830	3940			

TABLE 7

Value of Total Imports of Bottles and Other Containers, 1821–1929

(Rounded figures, 000's omitted)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1821	..[a]	1839	200	1857	70	1875	30
1822	..	1840	140	1858	60	1876	20
1823	..	1841	100	1859	70	1877	20
1824	..	1842	90	1860	70	1878	20
1825[b]	90	1843[c]	10	1861	70	1879	80
1826	150	1844	40	1862	90	1880	240
1827	180	1845	50	1863	30	1881	330
1828	130	1846	70	1864	20	1882	490
1829	80	1847	70	1865	110	1883	500
1830	70	1848	70	1866	300	1884	530
1831	100	1849	80	1867	230	1885	570
1832	140	1850	100	1868[d]	160	1886	600
1833	140	1851	130	1869	230	1887	730
1834	140	1852	110	1870	120	1888	810
1835	140	1853	140	1871	80	1889	840
1836	290	1854	150	1872	80	1890	940
1837	290	1855	150	1873	80	1891	920
1838	160	1856	110	1874	30	1892	740

Data from *Commerce and Navigation.* Figures include the following: 1821–1824 black quart bottles only, the values of which were not reported separably; 1825–1854 bottles, vials, and demijohns; 1855–1861 bottles and demijohns (vials not reported separably after 1854 but almost certainly are included in these totals); 1861–1864 glass bottles (vials and demijohns not separably reported after 1861 but almost certainly are included in these totals); 1865–1872 glass bottles and bottles containing liquors (1870–1872 value figures for bottles containing liquors obviously incomplete); 1873–1883 glass bottles (does not include value of bottles imported containing liquors since quantities but no values are reported); 1884–1894 flint and lime glass bottles and vials, empty and filled, and green and colored glass bottles, vials, demijohns, and carboys, empty and filled (does not include those imported containing liquors since quantities but no values are reported); 1895–1898 the same as 1894 plus bottles, cut, engraved, and decorated, 1899–1913 glass bottles, vials, demijohns, carboys, and jars, flint, lime, or lead, and plain, green, or colored, empty or filled (does not include value of bottles imported containing liquors since values not reported—only quantities—or value included with value of contents); 1914–1917 glass bottles, vials, jars, demijohns, and carboys, filled and empty (apparently values of bottles imported containing liquors not omitted); 1918–1921 the same, and bottles and bottle glassware; 1922 the same and glass containers, plain, green, or colored, molded or pressed flint, lime, or lead; 1923–1929 bottles and bottle glassware, glass containers, plain, green, or colored, molded or pressed, flint, lime, or lead, and bottles and decanters, cut, engraved, or otherwise decorated (values of bottles imported containing liquors omitted from value figures, since only quantity reported).

[a] 1821–1824 value not reported; quantities (in gross, round figures) were: 1821—10,000; 1822—15,000; 1823—12,000; 1824—10,000.

[b] 1821–1842 year ending September 30; 1843–1917 year ending June 30; 1918 and after, year ending December 31.

[c] 1843 figures for nine months only.

[d] 1821–1867 import entries; 1868 and after ,imports for home consumption.

TABLE 7 (Continued)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1893	740	1903	480	1913	850	1923	510
1894	490	1904	560	1914	1360	1924	740
1895	540	1905	690	1915	820	1925	900
1896	390	1906	760	1916	760	1926	860
1897	600	1907	1000	1917	780	1927	1330
1898	320	1908	900	1918	190	1928	1210
1899	370	1909	650	1919	180	1929	1390
1900	450	1910	860	1920	290		
1901	490	1911	960	1921	320		
1902	470	1912	940	1922	880		

TABLE 8

Value of Exports of Bottles and Containers, 1914–1929
(Rounded figures, 000's omitted)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1914	710	1918	2780	1922	2360	1926	3100
1915	770	1919	5280	1923	3500	1927	3080
1916	2170	1920	9570	1924	2870	1928	3510
1917	2430	1921	4550	1925	2940	1929	3570

Data from *Commerce and Navigation.* Not reported before 1914 This series presumably includes all exports of bottles and containers; the series of *Commerce and Navigation* appears to cover bottles, vials, jars, demijohns, and carboys.

TABLE 9

Value of Total Imports of Flint and Certain Other Glassware, 1821–1860
(Rounded figures, 000's omitted)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1821[a]	240	1831	340	1841	330	1851	710
1822	320	1832	500	1842	380	1852	690
1823	430	1833	330	1843[b]	30	1853	730
1824	340	1834	380	1844	200	1854	900
1825	220	1835	440	1845	420	1855	810
1826	290	1836	620	1846	390	1856	670
1827	280	1837	590	1847	460	1857	640
1828	380	1838	310	1848	600	1858	430
1829	300	1839	660	1849	250	1859	660
1830	250	1840	360	1850	500	1860	910

Data from *Commerce and Navigation* Figures include 1821–1842 all glass and glassware except bottles, jars, vials, demijohns, carboys, and window glass; 1843–1860 all glass and glassware except bottles, jars, vials, demijohns, carboys, window glass, and plate glass.

[a] 1821–1842 year ending September 30; 1843–1860 year ending June 30.

[b] Figures for 1843 nine months only.

TABLE 10

Value of Imports of Flint and Lime Glass and Glassware, 1861–1890
(Rounded figures, 000's omitted)

Year	Dollar value			
	Total flint and lime glassware	Glass and glassware not specified[a]	Decorated and fine flint and lime glassware[b]	Plain flint and lime glassware[c]
1861	380	130	190	60
1862	270	70	140[d]	..[e]
1863	400	60	260	..
1864	300	110	110	..
1865	260	60	150	50
1866	680	330	260	90
1867	980	360	450	170
1868	740	320[f]	300[f]	120[f]
1869	910	400	380	130
1870	1040	620	310	110
1871	1220	680	370	170
1872	1740	1050	450	240
1873	1980	730	1010	240
1874	1630	1010	470	150
1875	1470	920	450	100
1876	1250	620	570	60
1877	1050	500	500	50

Data from *Commerce and Navigation.* Figures include the following: 1861–1872 porcelain, Bohemian, painted, colored, and ornamented glass and glassware as well as cut glassware, plain glassware, manufactures of glass not specified; 1873–1883 porcelain, Bohemian, cut, engraved, painted, stained, silvered and gilded glass and glassware (not including plate or window glass, silvered), plain, molded, or pressed glassware, not cut, engraved, etc., and manufactures of glass not specified; 1884–1890 articles of glass, cut, engraved, painted, colored, printed, stained, silvered (not plate or window glass) glass and glassware as well as porcelain, Bohemian, and chemical glassware, and plain, molded, or pressed flint or lime glassware, not specifically provided for, and manufactures of glass not specified. This series in fact includes all other glassware (window, plate, and containers already eliminated) except watch crystals and optical glassware, which have been omitted whenever possible. Also in 1861 silvered glass and silvered and gilded glass have been omitted since it seems probable that these were largely plate glass or mirrors.

[a] This series is composed of glass imports designated "not specified."

[b] This series is composed of all portions of the total series other than plain and not specified; these classifications are clearly described in *Commerce and Navigation* as fine and decorated flint and lime glassware, though not in such words.

[c] This series is composed of glass imports designated plain.

[d] From 1862 to 1864, plain and cut glass reported together. In these years both the plain and fine glassware totals are therefore too low since the combined cut and plain amounts are not included in their proper series. These figures are included in the total series, however.

[e] Not reported separably 1862–1864.

[f] 1861–1867 import entries; 1868–1890 imports for home consumption.

TABLE 10 (Continued)

Year	Dollar value			
	Total flint and lime glassware	Glass and glassware not specified[a]	Decorated and fine flint and lime glassware[b]	Plain flint and lime glassware[c]
1878	1030	540	460	30
1879	1230	690	500	40
1880	1710	950	720	40
1881	2140	1280	800	60
1882	2580	1650	870	60
1883	3030	1930	1020	80
1884	2070	980	1030	60
1885	1800	830	920	50
1886	1760	660	1090	10
1887	2100	900	1170	30
1888	2250	1040	1160	50
1889	2180	1020	1090	70
1890	2100	960	1090	50

TABLE 11

VALUE OF TOTAL IMPORTS OF PRESSED, BLOWN, AND OTHER GLASS AND GLASSWARE, 1890–1929
(Rounded figures, 000's omitted)

Year	Dollar value	Year	Dollar value	Year	Dollar value	Year	Dollar value
1890	2100	1900	1520	1910	2570	1920	2590
1891	2120	1901	1570	1911	2400	1921	3240
1892	3140	1902	1710	1912	2470	1922	4420
1893	2660	1903	2010	1913	2530	1923	4200
1894	1980	1904	2270	1914	2580	1924	5070
1895	2400	1905	2210	1915	1600	1925	4120
1896	2060	1906	1700	1916	720	1926	4910
1897	1820	1907	2600	1917	630[a]	1927	6700
1898	1170	1908	..	1918	790	1928	6350
1899	1280	1909	1890	1919	8 0	1929	6350

Data from *Commerce and Navigation* This series includes all imports except plate, window glass, bottles and containers (eliminated in every case where separably reported), beads, optical goods of all types, and duty-free glass. The constituent elements changed so frequently that it is futile to attempt to enumerate them.

[a] 1890–1917 year ending June 30; 1918 and after, year ending December 31.

TABLE 12

VALUE OF EXPORTS OF PRESSED, BLOWN, AND OTHER GLASS AND GLASSWARE, 1914–1929

(Rounded figures, 000's omitted)

Year	Dollar value			
	Total pressed, blown, and other glass and glassware[a]	Plain tableware[b]	Lighting glassware[b]	Cut and decorated glassware[b]
1914	2670	..	..	..
1915	2510	..	..	..
1916	5460	..	..	..
1917	5410	..	..	..
1918	5720	..	..	140
1919	8800	..	..	270
1920	13560	..	..	420
1921	8100	..	..	180
1922	4730	1440	1100	190
1923	5980	2280	1260	210
1924	4920	1760	1060	170
1925	5050	1750	1080	160
1926	5370	1660	980	170
1927	4910	1440	1000	140
1928	5370	1380	970	130
1929	6010	1520	1070	130

Data from *Commerce and Navigation*. All series begin with first year entered in the table.

[a] The total export series includes all glass exports except exports of window glass, plate glass, and bottles and containers.

[b] This series includes exports so designated in the tables of *Commerce and Navigation* (in certain cases the wording of the description has been slightly changed).

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